

VDatum

Vertical Datum Transformation Tool

Stephen A. White
(Program Manager)

July 14, 2016

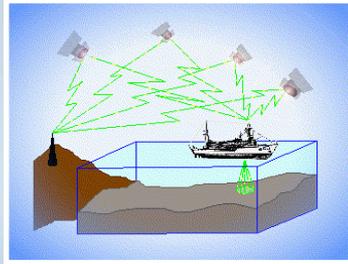


National Oceanic and Atmospheric Administration

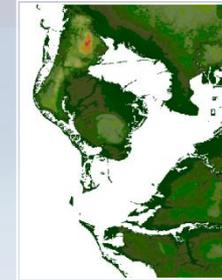
What Vertical Datum is My Data in?

Ellipsoidal Datums

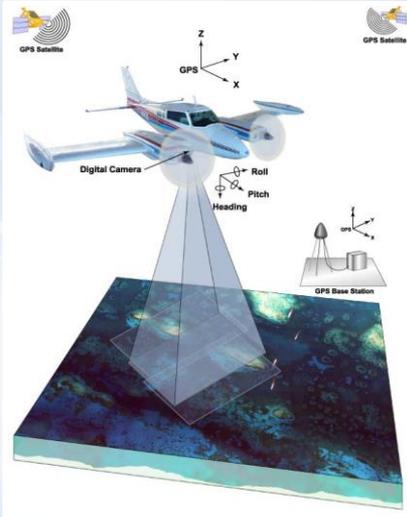
Orthometric Datums



RTK-GPS vertical
referencing
Hydrographic Surveys



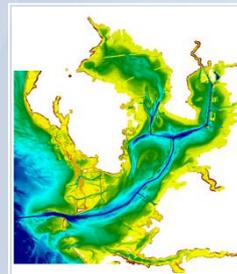
USGS
Topography



Lidar



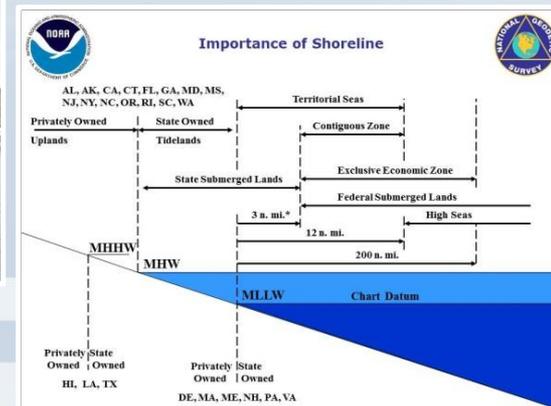
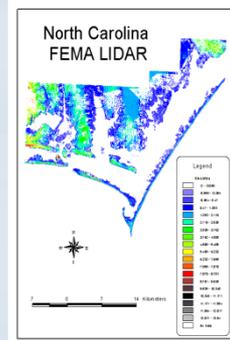
GPS



NOAA Bathymetry
(MLLW)



Tidal Datums

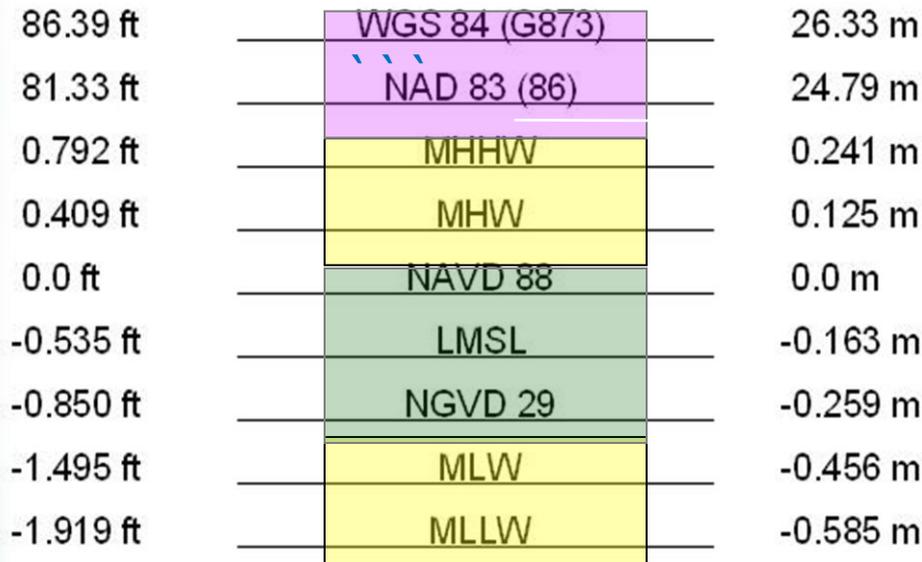


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All elevation data is referenced to a vertical datum.

BUT there are a many different vertical datums in use around the nation

Relationship of vertical datums for Tampa Bay:



ITRF,
WGS 84,
NAD 83 (NSRS)



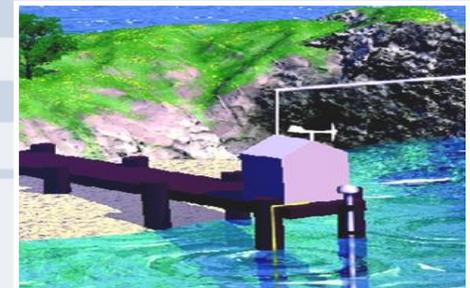
Orthometric Datums

NAVD 88,
NGVD 29



MHHW, MHW,
MTL, DTL,
LMSL,
MLW, MLLW

Tidal Datums



For elevation data sets to be blended together they must be referenced to same vertical datum.



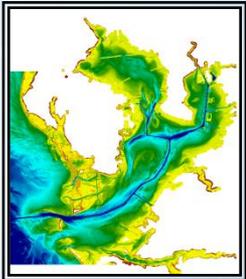
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Development and Use of VDatum

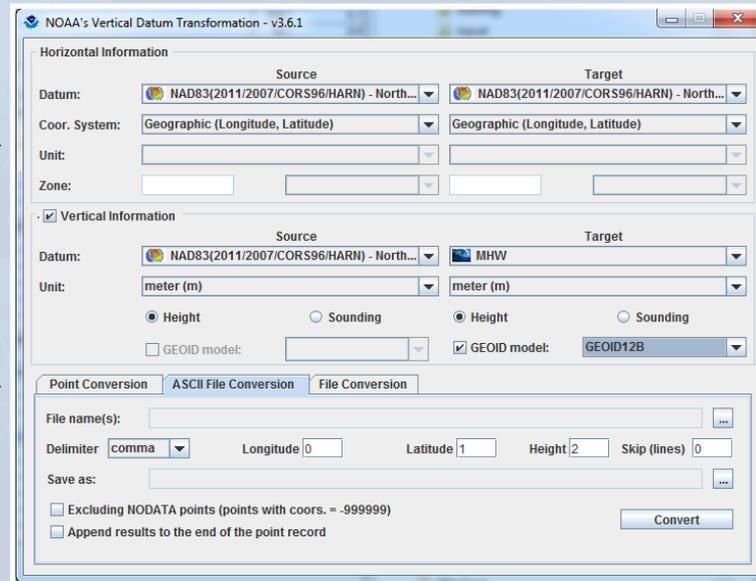
Mapping the Land-Sea Interface:
VDatum converts elevation data (heights and soundings) among different vertical datums



USGS Topography

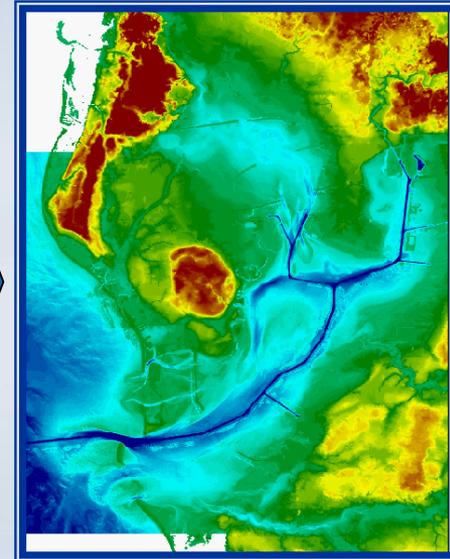


NOAA Bathymetry



The screenshot shows the NOAA's Vertical Datum Transformation - v3.6.1 application window. It is divided into several sections:

- Horizontal Information:** Source and Target datums are both set to NAD83(2011/2007/CORS96/HARN) - North... The coordinate system is Geographic (Longitude, Latitude) for both. Units and zones are empty.
- Vertical Information:** The 'Vertical Information' checkbox is checked. Source datum is NAD83(2011/2007/CORS96/HARN) - North... and the target is MHW. Units are set to meter (m). The 'Height' radio button is selected for both source and target. The 'GEOID model' dropdown is set to GEOID12B.
- Conversion Options:** 'Point Conversion', 'ASCII File Conversion', and 'File Conversion' tabs are visible. The 'File Conversion' tab is active.
- File Conversion Settings:** File name(s) is empty. Delimiter is 'comma'. Longitude is 0, Latitude is 1, Height is 2, and Skip (lines) is 0. The 'Save as:' field is empty.
- Options:** 'Excluding NODATA points (points with coords. = -999999)' and 'Append results to the end of the point record' are unchecked.
- Buttons:** A 'Convert' button is located at the bottom right.

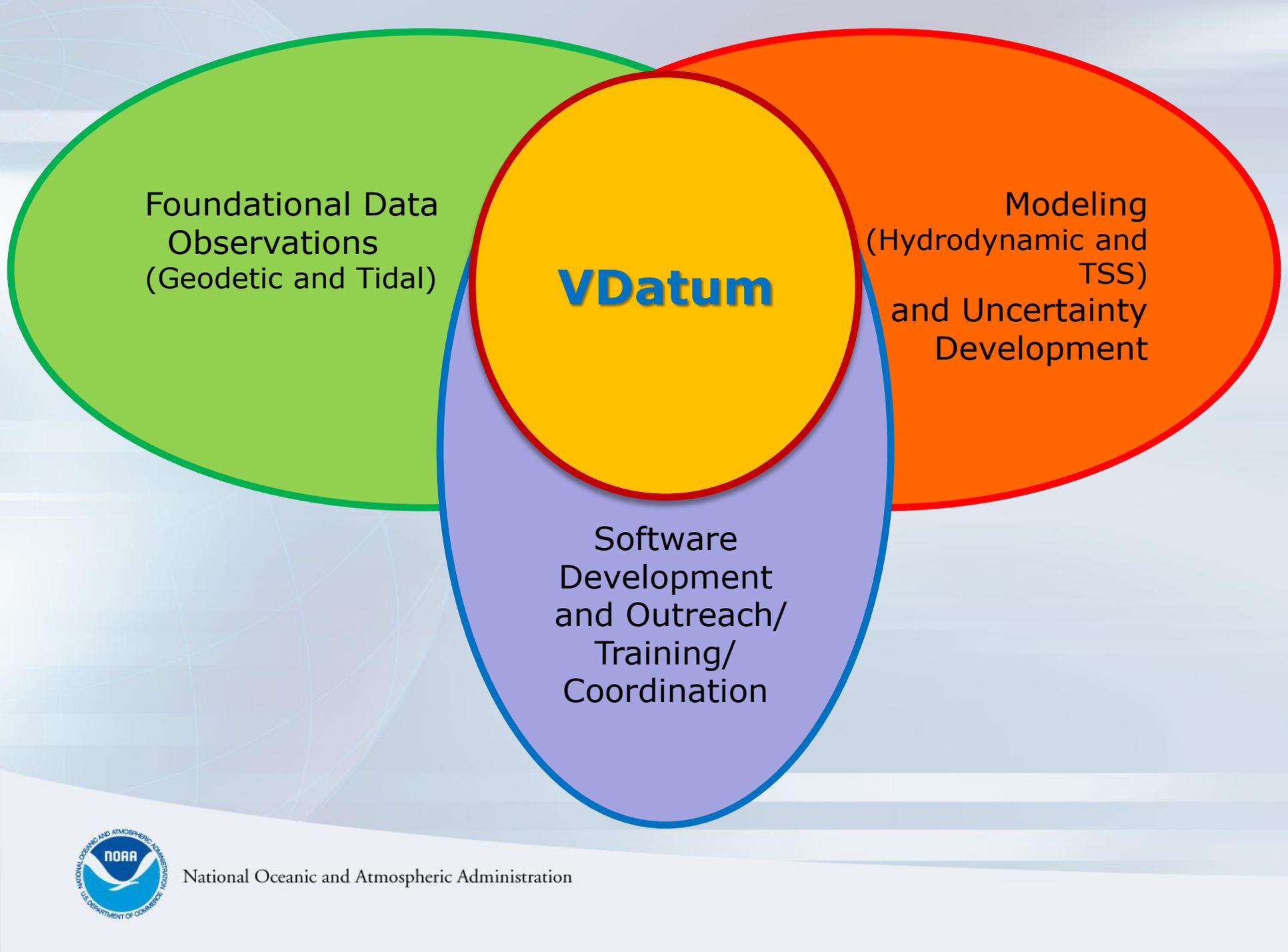


VDatum is a Java application developed jointly by :

- National Geodetic Survey (NGS)
 - Office of Coast Survey (OCS)
- Center for Operational Oceanographic Products & Services (CO-OPS)



National Oceanic and Atmospheric Administration

A Venn diagram with three overlapping ovals. The top-left oval is green and contains the text 'Foundational Data Observations (Geodetic and Tidal)'. The top-right oval is orange and contains the text 'Modeling (Hydrodynamic and TSS) and Uncertainty Development'. The bottom oval is purple and contains the text 'Software Development and Outreach/ Training/ Coordination'. The central intersection of all three ovals is yellow and contains the text 'VDatum' in blue.

Foundational Data
Observations
(Geodetic and Tidal)

VDatum

Modeling
(Hydrodynamic and
TSS)
and Uncertainty
Development

Software
Development
and Outreach/
Training/
Coordination



National Oceanic and Atmospheric Administration

3 Categories of Vertical Datums:

- **3D/Ellipsoidal Datums:**
 - Realized through space-based systems, such as GPS
- **Orthometric Datums:**
 - Based on a form of mean sea level
- **Tidal Datums:**
 - a standard elevation defined from water level observations during a specific phase of the tide



Vertical Datum Transformation "Roadmap"

3D Datums

Orthometric Datums

Tidal Datums

WGS 84 (G1150)

WGS 84 (G873)

WGS 84 (G730)

WGS 84 (orig.)

ITRF2000

ITRF97

ITRF96

ITRF94

ITRF93

ITRF92

ITRF91

ITRF90

ITRF89

ITRF88

SIO/MIT 92

NEOS 90

PNEOS 90

Calibrated Helmert Transformations

VERTCON

NAD83 (NSRS)

GEOID99,
GEOID03,
GEOID09

NGVD 29

NAVD 88

TSS
(Topography of
the Sea
Surface)

Tide Models

LMSL

MHHW

MHW

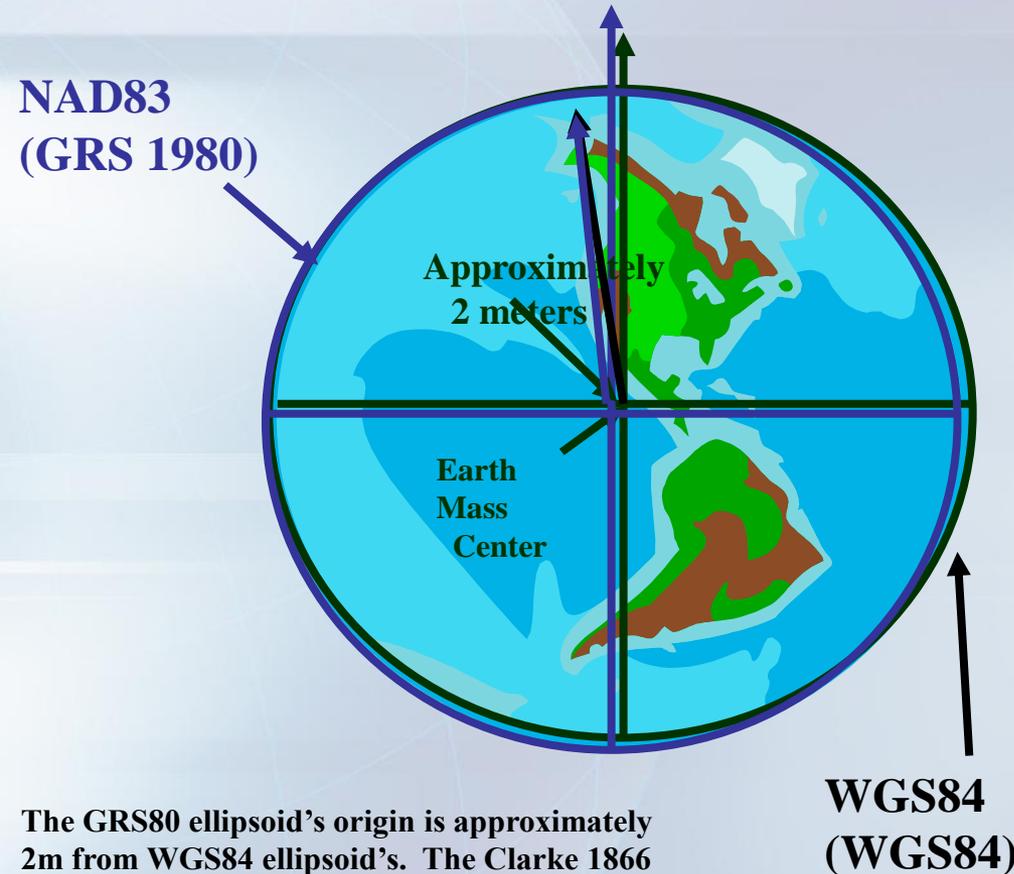
MTL

DTL

MLW

MLLW

3D/Ellipsoid Datums



- Calculation of geographic position on this irregular surface is very complex. A simpler model is needed.
- This simplified mathematical surface is the *ellipsoid*.
- An ellipsoid approximates the shape of the earth, a datum defines the position of the ellipsoid relative to the center of the earth. A datum provides a frame of reference for measuring locations on the surface of the earth.

The GRS80 ellipsoid's origin is approximately 2m from WGS84 ellipsoid's. The Clarke 1866 ellipsoid's origin is approximately 236 m from WGS84 ellipsoid's



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14-parameter transformation

Orthometric Datums and the GEOID

Ellipsoid to Orthometric

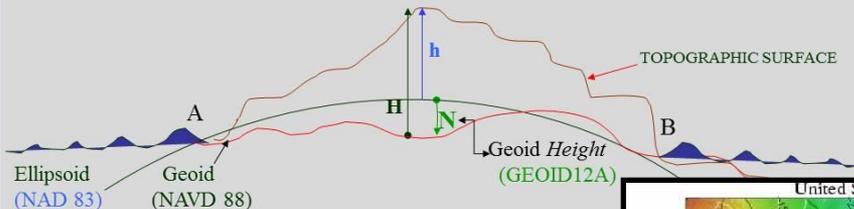
+ Ellipsoid, Geoid, and Orthometric Heights

H = Orthometric Height (NAVD 88)

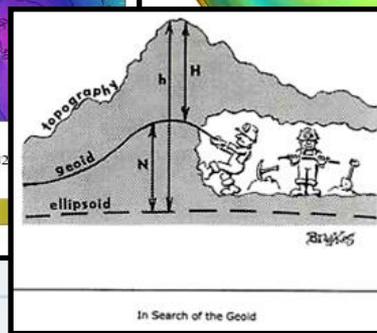
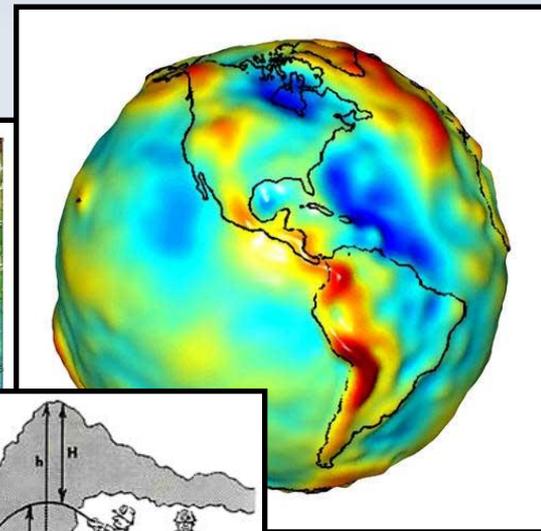
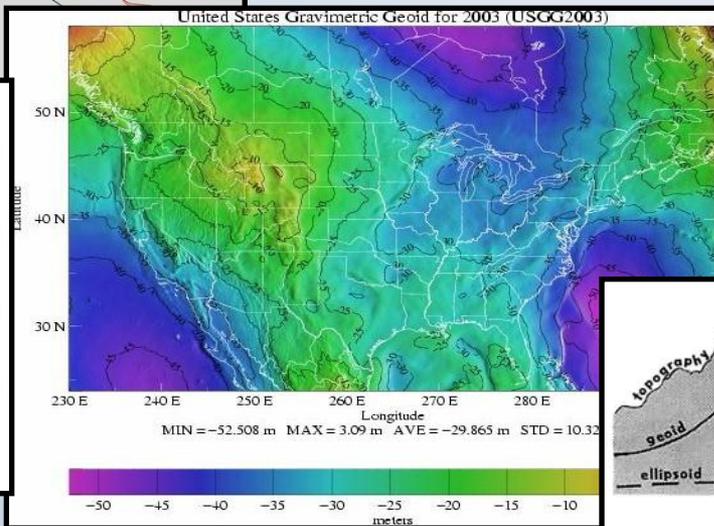
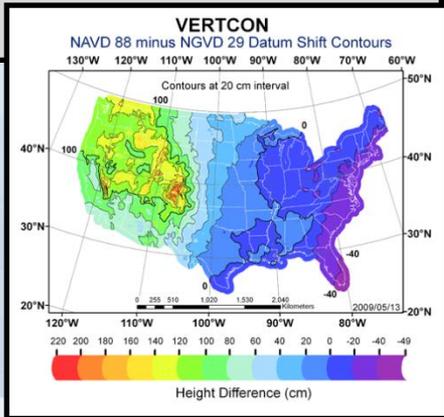
h = Ellipsoidal Height (NAD 83)

N = Geoid Height (GEOID 12A)

$$H = h - N$$



- NAVD88 is based on an adopted elevation at Point Rimouski (Father's Point). It uses Helmert orthometric heights as an approximation to true orthometric heights.
- GEOID: "The *equipotential surface* of the Earth's gravity field which best fits, in the least squares sense, (global) mean sea level."
- Can't see the surface or measure it directly.
- Can be modeled from gravity data as they are mathematically related.

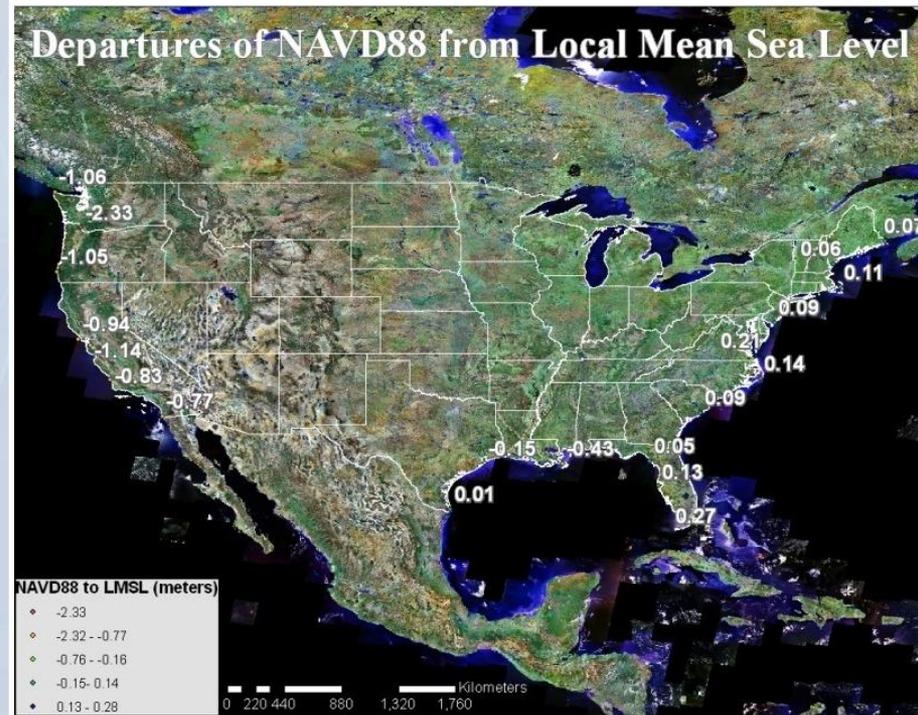


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biquadratic interpolation

Topography of the Sea Surface

The **Topography of the Sea Surface (TSS)** is defined as the elevation of the North American Vertical Datum of 1988 (NAVD88) relative to local mean sea level (LMSL).



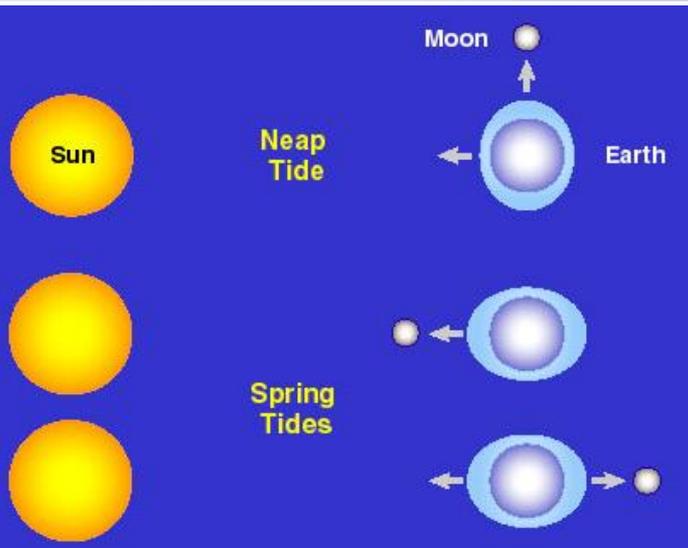
- This grid provides compensation for the local variations between a mean sea level surface and the NAVD88 geopotential surface.
- A positive value specifies that the NAVD88 reference value is further from the center of the Earth than the local mean sea level surface.



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bilinear interpolation

Tidal Datums



- A vertical datum is called a tidal datum when it is defined by a certain phase of the tide.
- National Tidal Datum Epoch (NTDE): is a specific 19-year period that spans the longest periodic tidal variations resulting from astronomical tide-producing forces.
- The fundamental base from which most coastal and marine boundaries are determined.
- Also important for referencing soundings and depicting shorelines on nautical charts.



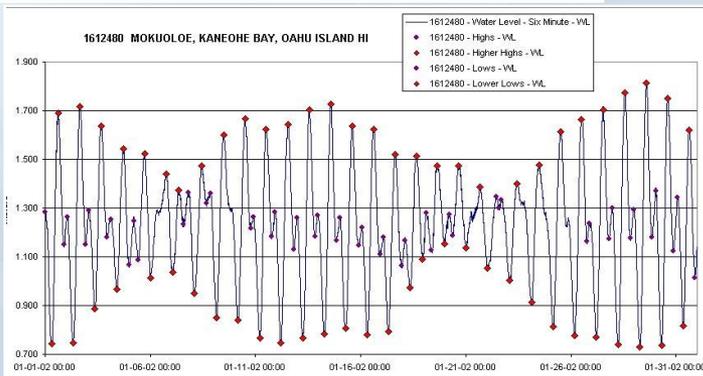
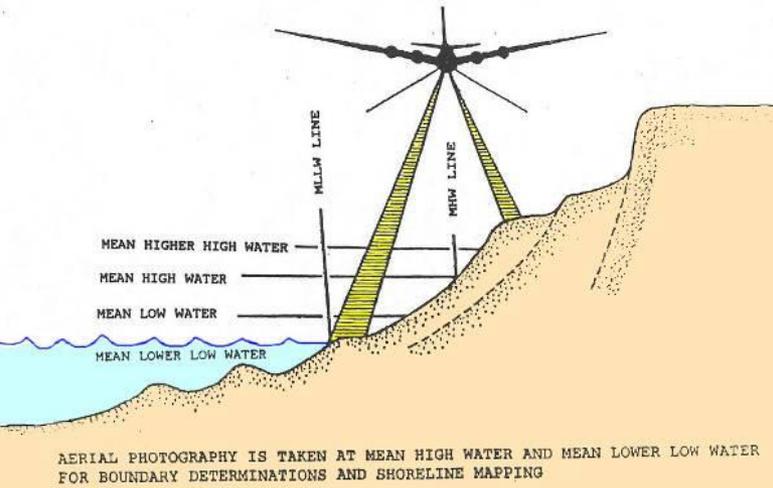
National Water Level Observation Network (NWLON)



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Tidal Datums

TIDES - SUPPORT TO NAUTICAL CHARTING PHOTOGRAMMETRY APPLICATIONS

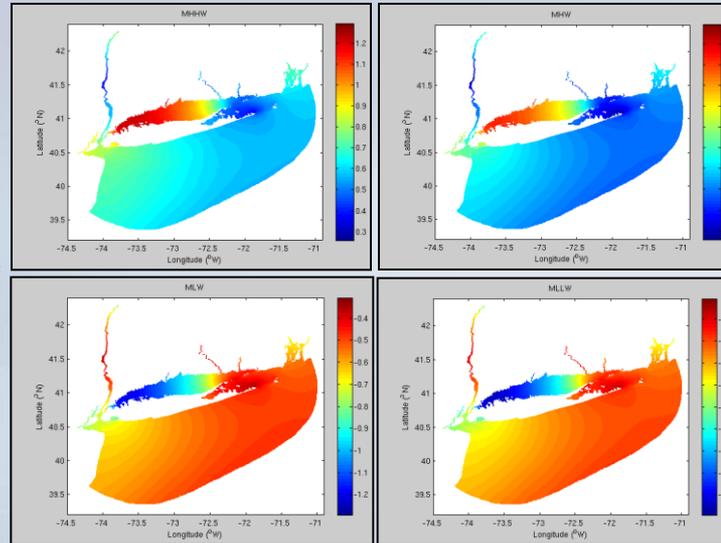
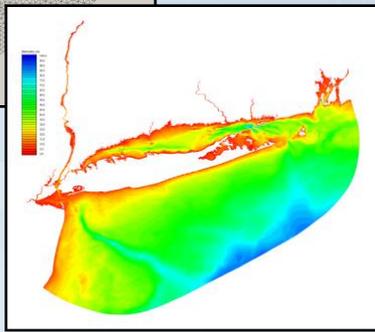


- Mean Higher High Water (MHHW): defined as the arithmetic mean of the higher high water heights of the tide over a specific 19-year Metonic cycle denoted as the NTDE.
- **Mean High Water (MHW)**: defined as the arithmetic mean of the high water heights observed over a specific 19 year cycle.
- Mean Sea Level (MSL): defined as the arithmetic mean of hourly heights observed over a specific 19 year cycle.
- Mean Low Water (MLW): defined as the arithmetic mean of the low water heights observed over a specific 19 year cycle.
- **Mean Lower Low Water (MLLW)**: defined as the arithmetic mean of the lower low water heights of the tide observed over a specific 19 year cycle.
- Mean Tide Level (MTL): a tidal datum which is the average of Mean High Water and Mean Low Water.
- Diurnal Tide Level (DTL): a tidal datum which is the average of Mean Higher High Water and Mean Lower Low Water.

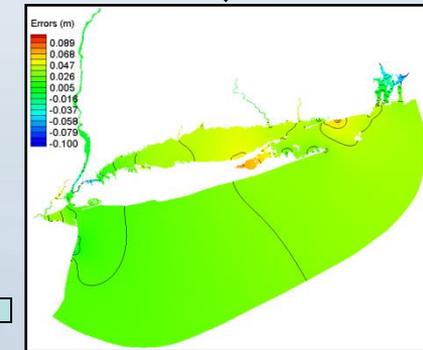


Tidal Datums and Hydrodynamic Modeling

Finite Element grid is created and populated with bathymetry

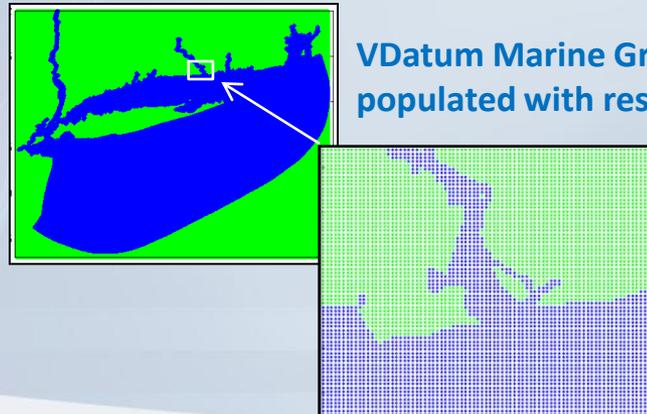


Tidal Datum fields are derived from ADCIRC (Advanced Circulation) Model, simulations are made on cluster computers at NOAA's Earth System Research Laboratory



Correct results by spatially interpolating errors with TCARI (Tidal Constituent and Residual Interpolation)

VDatum Marine Grid is populated with results

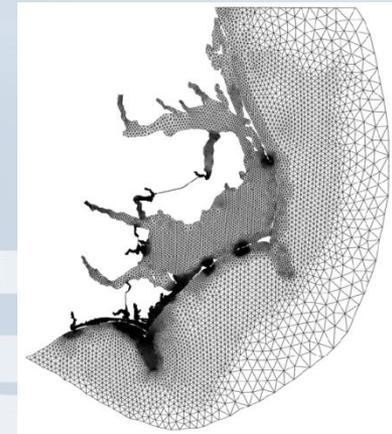
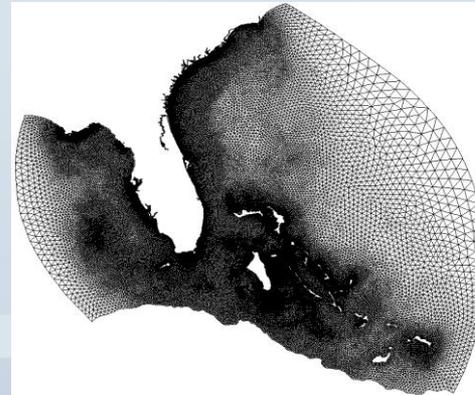
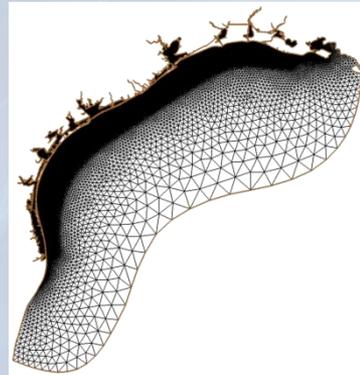
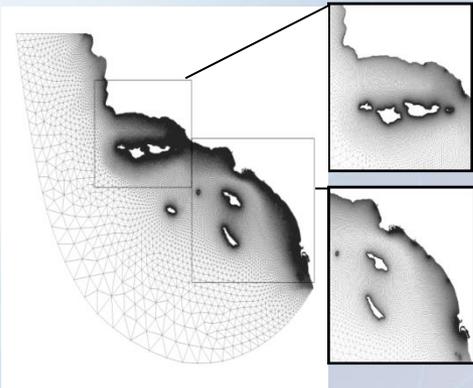
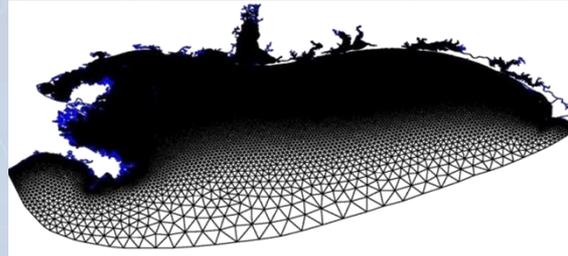
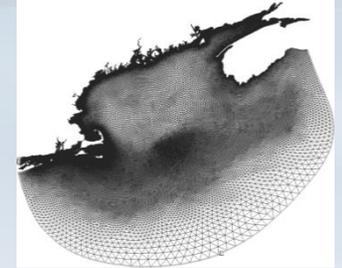
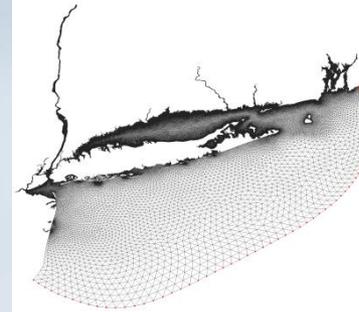
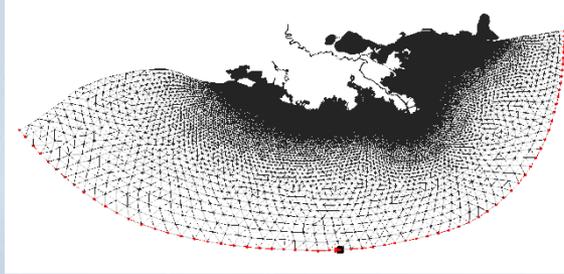
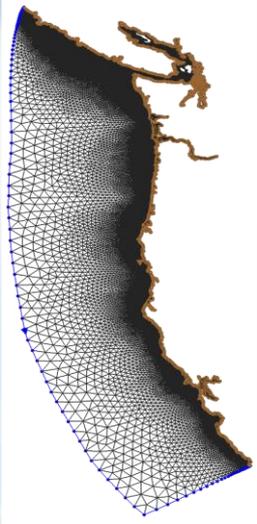


bilinear interpolation



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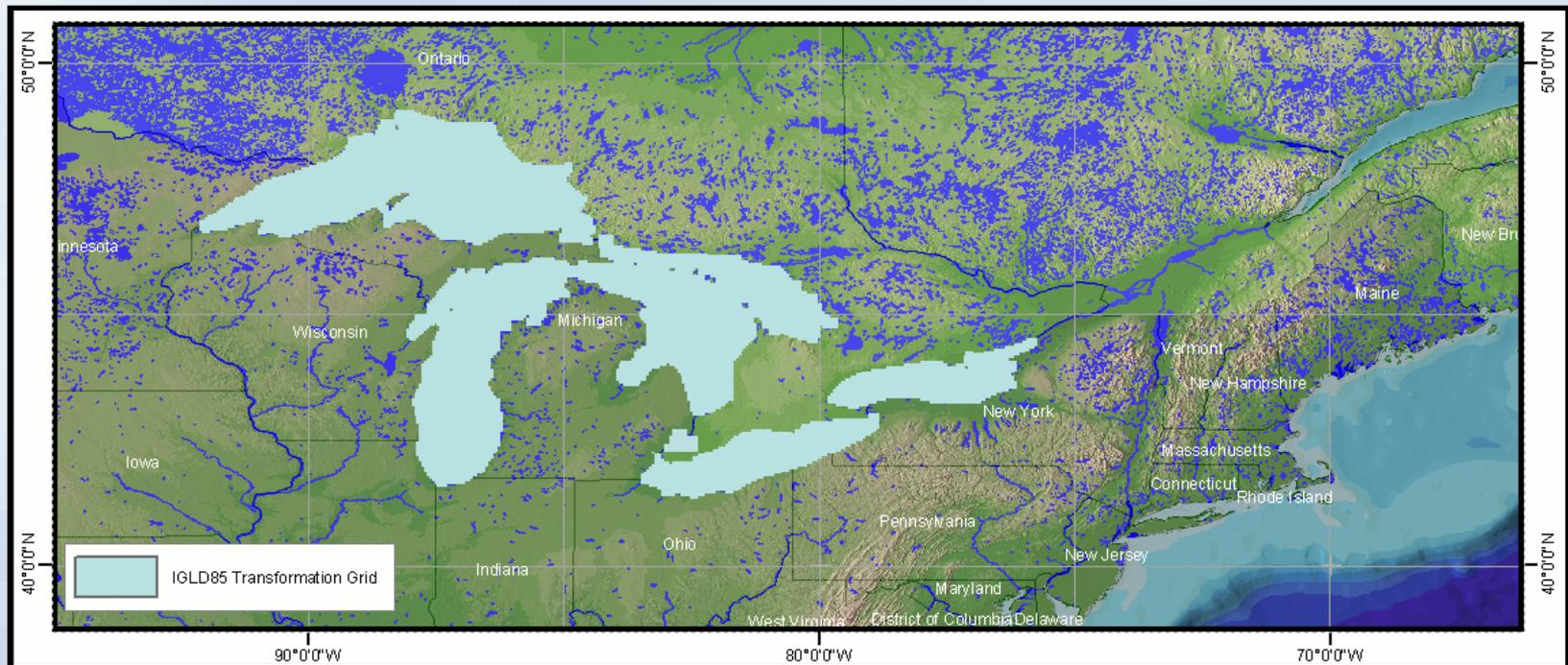
ADCIRC Modeling in Support of VDatum



National Oceanic and Atmospheric Administration

VDatum: IGLD85

- Conversions between IGLD 85 and NAVD 88 are provided based on the NAVD 88 gravity model (<http://www.ngs.noaa.gov/TOOLS/Navdgrav/navdgrav.html>) and the hydraulic corrector model.



VDatum Website: vdatum.noaa.gov

(Version 3.6 Released, May 13, 2016)



VERTICAL DATUM TRANSFORMATION

INTEGRATING AMERICA'S ELEVATION DATA

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Welcome to VDatum!

VDatum is a free software tool being developed jointly by NOAA's National Geodetic Survey (NGS), Office of Coast Survey (OCS), and Center for Operational Oceanographic Products and Services (CO-OPS). VDatum is designed to vertically transform geospatial data among a variety of tidal, orthometric and ellipsoidal vertical datums - allowing users to convert their data from different horizontal/vertical references into a common system and enabling the fusion of diverse geospatial data in desired reference levels.

Features

VDatum software is written in Java, so it runs on Mac OS X, Unix, VMP, and Windows.

Where available and uncertainties are established, VDatum supports the conversions among following:

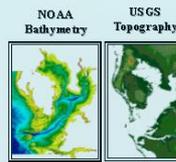
- **Coordinate Systems:** Geographic, UTM, State Plane Coordinates (SPC), and geocentric (ECEF)
- **Horizontal Datums:** NAD27, NAD83(1986), and NAD83(HARN); and ellipsoidal datums such as ITRF, WGS84, and NAD83 serializations
- **Vertical Datums:**
 - **Ellipsoidal Datums:** NAD83, WGS84, ITRF88, ITRF89, ITRF90, NEOS 90, PNEOS 90, ITRF91, ITRF92, SIO/MIT 92, ITRF93, ITRF94, ITRF96, ITRF97, IGS97, ITRF2000, IGS00, IGS05, ITRF2005, IGS05, ITRF2008, IGS08, WGS84(transit), WGS84(G730), WGS84(G873), WGS84(G1150), WGS84(G1674), NAD83(PACP00), NAD83(MARP00)
 - **Orthometric Datums:** NAVD88, NGVD29, PRVD02, VIVD09, ASVD02, GUVD04, NMVD03, HAWAII EGM2008, EGM1996, and EGM1984
 - **Tidal Datums:** MLLW, MLW, LMSL, DTL, MTL, MHW, LWD, and MHHW
 - IGLD85
- **GEOID models:** GEOID12B, GEOID12A, GEOID09, GEOID06 (Alaska only), GEOID03, GEOID99, and GEOID96
- **EGM models:** EGM2008, EGM1996, and EGM1984
- **Supported file format:** text(ASCII), LIDAR(.LAS) version 1.0 to 1.2, ESRI ASCII Raster(.ASC), and ESRI 3D shapefile

[Download](#)

Download the newest VDatum (v3.6.1) and its datasets.

[Animated tutorial!](#)

The VDatum Demonstration Project in Tampa Bay, Florida



NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Source Target

Datum: NAD83(2011/2007/CORS96/HARN) - North... NAD83(2011/2007/CORS96/HARN) - North...

Coord. System: UTM (Easting, Northing) UTM (Easting, Northing)

Unit: meter (m) meter (m)

Zone: 18 18

Vertical Information

Source Target

Datum: NAD83(2011/2007/CORS96/HARN) - North... MHW

Unit: meter (m) meter (m)

Height Sounding Height Sounding

GEOID model: GEOID model: GEOID12B

Point Conversion ASCII File Conversion File Conversion

Input Output

Easting: Convert Easting: File Report to DMS

Northing: Reset Northing: Vertical Uncertainty

Height: DMS Height:



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VDatum: Documentation and Support



VERTICAL DATUM TRANSFORMATION

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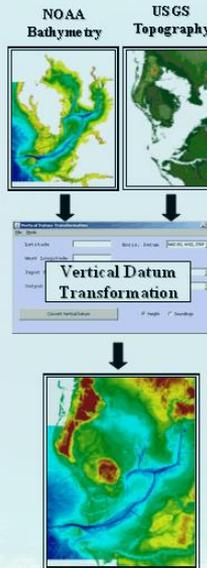
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- Est. of VDatum Uncertainties
- User FAQs
- User Guide
- Command-line Guide
- Datum Tutorial
- Manual, Presentations & Publications
- Datum Demonstration Project in Tampa Bay, Florida
- Transformation Grid Format



Integrated Bathy/Topo DEM

Manual, Presentations and Publications

Manual

- VDatum Manual for Development and Support of NOAA's Vertical Datum Transformation Tool, VDatum, Version 1. 01, June 2012.

Presentations

- White, S. A. (2013). VDatum: Vertical Datum Transformation Tool. Presented to the Hydrographic Services Review Panel.

Publications

2013

- Yang, J., E. Myers, I. Jeong, S. White (2013). VDatum for the Coastal Waters of Puerto Rico and the U. S. Virgin Islands: Tidal Datums, Marine Grid, and Sea Surface Topography. NOAA Technical Memorandum NOS CS 33.
- Yang, Z., E. Myers, I. Jeong, S. White (2013). VDatum for the Gulf of Maine: Tidal Datums and Topography of the Sea Surface. NOAA Technical Memorandum NOS CS 31.
- Hess, K., I. Jeong, S. White (2013). Revised VDatum For Eastern Florida. NOAA Technical Memorandum NOS CS 30.
- Xu, J., E. Myers, I. Jeong, S. White (2013). VDatum For Coastal Waters of Texas and Western Louisiana: Tidal Datums and Topography of the Sea Surface. NOAA Technical Memorandum NOS CS 29.

2012

- Yang, Z., E. Myers, I. Jeong, S. White (2012). VDatum For Coastal Waters From The Florida Shelf to the South Atlantic Bight: Tidal Datums, Marine Grids, And Sea Surface Topography. NOAA Technical Memorandum NOS CS 27.

2011

2010

- Yang, Z., E. Myers, S. White (2010). VDatum For Eastern Louisiana And Mississippi Coastal Waters: Tidal Datums, Marine Grids, And Sea Surface Topography. NOAA Technical Memorandum NOS CS 19.
- Yang, Z., E. Myers, S. White (2010). VDatum For Great South Bay, New York Bight And New York Harbor: Tidal Datums, Marine Grids, and Sea Surface Topography. NOAA Technical Memorandum NOS CS 21.
- Xu, J., E. Myers, S. White (2010). VDatum for the Coastal Waters of North/Central California, Oregon and Western Washington: Tidal Datums and Sea Surface Topography. NOAA Technical Memorandum NOS CS 22.

2009

Frequently Asked Questions

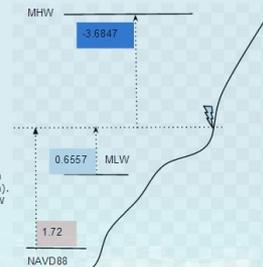
- Which OS does VDatum run on?
- I have the latest Java, however when I double click vdatum.bat, the command prompt window flashes for a split second and the application does not launch.
- Running "java -jar vdatum.jar" at the command prompt window gives me "java is not recognized as an internal or external command, operable program or batch file".
- I can't select any tidal datum, or NAD 27, NAD83(1986), NGVD29, IGLD85!
- I recieved a result of -999999.0. What does that mean?
- The -999999.0 is the no-data-value in our program. It occurs in areas where the transformations are invalid. In the tidal transformations, this -999999.0 value could mean that your elevation data are either out of the boundaries of our tidal transformation grids, or in the masked-out areas, i.e. inland or where are not covered by the tidal models.
- Why doesn't VDatum provide tidal datums inland?
- What are the VDatum bounding polygons and why are they utilized?
- While trying to convert from NAVD88 to MLLW, MLW, MHW, etc.. I got results showing that the MLLW and MLW are higher than MHW and MHHW. Could it be program bug or something mixed up?

No, it isn't a program bug, nor a mix up.

Let's consider the diagram on the right, assuming a point (at the lightning bolt) has following elevation values (height values):

- NAVD88: 1.72m
- MLW: 0.6557m
- MHW: -3.6847m

where the original elevation value is relative to NAVD88 (1.72m). Using VDatum to get elevation values referenced in MLW (0.6557m), and in MHW is (-3.6847m). Since the origin of MHW is above the origin of MLW, the elevation result of MHW will be less than that of MLW.



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VDatum: Interfaces

ONLINE VERTICAL DATUM TRANSFORMATION
INTEGRATING AMERICA'S ELEVATION DATA

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Horizontal Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North American tech	Datum:	NAD83(2011/2007/CORS96/HARN) - North American tech
Coord. System:	Geographic (Longitude, Latitude)	Coord. System:	Geographic (Longitude, Latitude)
Unit:	meter (m)	Unit:	meter (m)
Zone:	AL E - 0101	Zone:	AL E - 0101

Vertical Information

Source		Target	
Datum:	NAVD 88	Datum:	MHW
Unit:	meter (m)	Unit:	meter (m)
<input checked="" type="radio"/> Height <input type="radio"/> Sounding		<input checked="" type="radio"/> Height <input type="radio"/> Sounding	
<input type="checkbox"/> GEOID model:		<input checked="" type="checkbox"/> GEOID model: GEOID12B	

Point Conversion ASCII File Conversion

Input		Output	
Longitude:	-76.121520	Longitude:	-76.1215200
Latitude:	33.724339	Latitude:	33.7243390
Height:	0	Height:	-0.3113
<input type="checkbox"/> to DMS		Vertical Uncertainty: 7.9284 cm	

Vertical_Area: NCcoast11_8301

Leaflet | Select a point by clicking on map.

[Alternating Horiz. Datum](#) | [Ellipsoidal Datum](#) | [Orthometric Datum](#) | [Tidal Datum](#)

NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	NAD83(2011/2007/CORS96/HARN) - North...
Coord. System:	UTM (Easting, Northing)	Coord. System:	UTM (Easting, Northing)
Unit:	meter (m)	Unit:	meter (m)
Zone:	18	Zone:	18

Vertical Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	MHW
Unit:	meter (m)	Unit:	meter (m)
<input checked="" type="radio"/> Height <input type="radio"/> Sounding		<input checked="" type="radio"/> Height <input type="radio"/> Sounding	
<input type="checkbox"/> GEOID model:		<input checked="" type="checkbox"/> GEOID model: GEOID12B	

Point Conversion ASCII File Conversion File Conversion

Input		Output	
Easting:	<input type="text"/>	Easting:	<input type="text"/>
Northing:	<input type="text"/>	Northing:	<input type="text"/>
Height:	<input type="text"/>	Height:	<input type="text"/>
<input type="button" value="Convert"/>		<input type="button" value="Reset"/>	
<input type="checkbox"/> File Report <input type="checkbox"/> to DMS		Vertical Uncertainty	

VDatum Command-line User Guide

On This Page

This User Guide describes how to run VDatum version 3.x without the graphical user interface.

Point Conversion

Once you download VDatum software and its transformation grids, your computer is ready to transform geospatial data among several horizontal and vertical datums.

File Conversion

General syntax:

- For running VDatum with the graphical user interface:
java -jar vdatum.jar
- For help:
java -jar vdatum.jar -help
- For converting without GUI:
java -jar VDatum.jar <georeferencing_parameters> [<point_conversion>] [<file_conversion>]

Georeferencing Parameters

Syntax:

ihorz:<source horizontal datum>[:<coordinate system>:<units>:<zone>] [**ivert:**<source vertical datum>[:<units>[:<height/sounding>[:<geoid>]]]] **ohorz:**<target horizontal datum>[:<coordinate system>:<units>:<zone>] [**overt:**<target vertical datum>[:<units>[:<height/sounding>[:<geoid>]]]]

where:

Parameter	Description
ihorz	Provides details about horizontal information of the source data.
ivert	Provides details about vertical information of the source data. If omitted, the transform is considered to be 2-dimension.
ohorz	Provides details about target horizontal information. If omitted, result will be horizontally referenced in NAD83, geographic coordinates. When specify ohorz:ihorz , results are considered to be horizontally referenced exactly as source. This is especially for LIDAR conversion with source and target data are in State Plane coordinate system.
overt	Provides details about vertical information of the source data. If omitted, the transform is considered to be 2-dimension.
<coordinate system>	Either geo , utm , spc or xyz , corresponding to geographic coordinates, UTM coordinates, State Plane coordinates or geocentric coordinates. If omitted, the geographic coordinate system with horizontal coordinates in degrees (i.e., geo:deg) are used.



National Oceanic and Atmospheric Administration

Utilizing VDatum: Horizontal

NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	NAD83(2011/2007/CORS96/HARN) - North...
Coord. System:	UTM (Easting, Northing)	Coord. System:	Geographic (Longitude, Latitude)
Unit:	meter (m)	Unit:	Geographic (Longitude, Latitude)
Zone:	18	Unit:	UTM (Easting, Northing)
		Unit:	State Plane Coordinates (Easting, Northing)
		Unit:	Earth-centered Earth-fixed XYZ

Vertical Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	MHW
Unit:	meter (m)	Unit:	meter (m)
<input checked="" type="radio"/> Height	<input type="radio"/> Sounding	<input checked="" type="radio"/> Height	<input type="radio"/> Sounding
<input type="checkbox"/> GEOID model:		<input checked="" type="checkbox"/> GEOID model:	GEOID12B

Point Conversion | ASCII File Conversion | File Conversion

Input		Output	
Easting:	<input type="text"/>	Longitude:	<input type="text"/>
Northing:	<input type="text"/>	Latitude:	<input type="text"/>
Height:	<input type="text"/>	Height:	<input type="text"/>

File Report to DMS

Vertical Uncertainty:



Utilizing VDatum: Vertical

NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Target	NAD83(2011/2007/CORS96/HARN) - North...
Coord. System:	UTM (Easting, Northing)	Target	UTM (Easting, Northing)
Unit:	meter (m)	Target	meter (m)
Zone:	18	Target	18

Vertical Information

Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Target	MHW
Unit:	meter (m)	Target	meter (m)
<input checked="" type="radio"/> Height	<input type="radio"/> Sounding	<input checked="" type="radio"/> Height	<input type="radio"/> Sounding
<input type="checkbox"/> GEOID model:		<input checked="" type="checkbox"/> GEOID model:	GEOID12B

Point Conversion | ASCII File Conversion | File Conversion

Input	Output
Easting: <input type="text"/>	Easting: <input type="text"/>
Northing: <input type="text"/>	Northing: <input type="text"/>
Height: <input type="text"/>	Height: <input type="text"/>

File Conversion

Vertical Datum List:

- GEOID12B
- GEOID12A
- GEOID09
- GEOID06
- GEOID03
- GEOID99
- GEOID96
- EGM2008



Utilizing VDatum: Input

NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	NAD83(2011/2007/CORS96/HARN) - North...	
Coord. System:	UTM (Easting, Northing)	UTM (Easting, Northing)	
Unit:	meter (m)	meter (m)	
Zone:	18	18	

Vertical Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	MHW	
Unit:	meter (m)	meter (m)	
<input checked="" type="radio"/> Height	<input type="radio"/> Sounding	<input checked="" type="radio"/> Height	<input type="radio"/> Sounding
<input type="checkbox"/> GEOID model:		<input checked="" type="checkbox"/> GEOID model:	GEOD12B

Point Conversion | ASCII File Conversion | File Conversion

Input		Output	
Easting:	<input type="text"/> <input type="button" value="Convert"/>	Easting:	<input type="text"/> <input type="checkbox"/> File Report <input type="checkbox"/> to DMS
Northing:	<input type="text"/> <input type="button" value="Reset"/>	Northing:	<input type="text"/> <input type="text" value="Vertical Uncertainty"/>
Height:	<input type="text"/> <input type="button" value="DMS"/>	Height:	<input type="text"/>



Utilizing VDatum: Input

NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	NAD83(2011/2007/CORS96/HARN) - North...
Coord. System:	UTM (Easting, Northing)	Coord. System:	UTM (Easting, Northing)
Unit:	meter (m)	Unit:	meter (m)
Zone:	18	Zone:	18

Vertical Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	MHW
Unit:	meter (m)	Unit:	meter (m)
<input checked="" type="radio"/> Height	<input type="radio"/> Sounding	<input checked="" type="radio"/> Height	<input type="radio"/> Sounding
<input type="checkbox"/> GEOID model:		<input checked="" type="checkbox"/> GEOID model:	GEOID12B

Point Conversion | **ASCII File Conversion** | File Conversion

File name(s): final\coquina\coquina_nad83.xyz;D:\iocm\subset_area_las_final\coquina\fil_VD_coquina_mhw.xyz; ...

Delimiter: comma | Easting: 0 | Northing: 1 | Height: 2 | Skip (lines): 0

Save as: \subset_area_las_final\coquina\result ...

Exclude points (points with coords. = -999999)

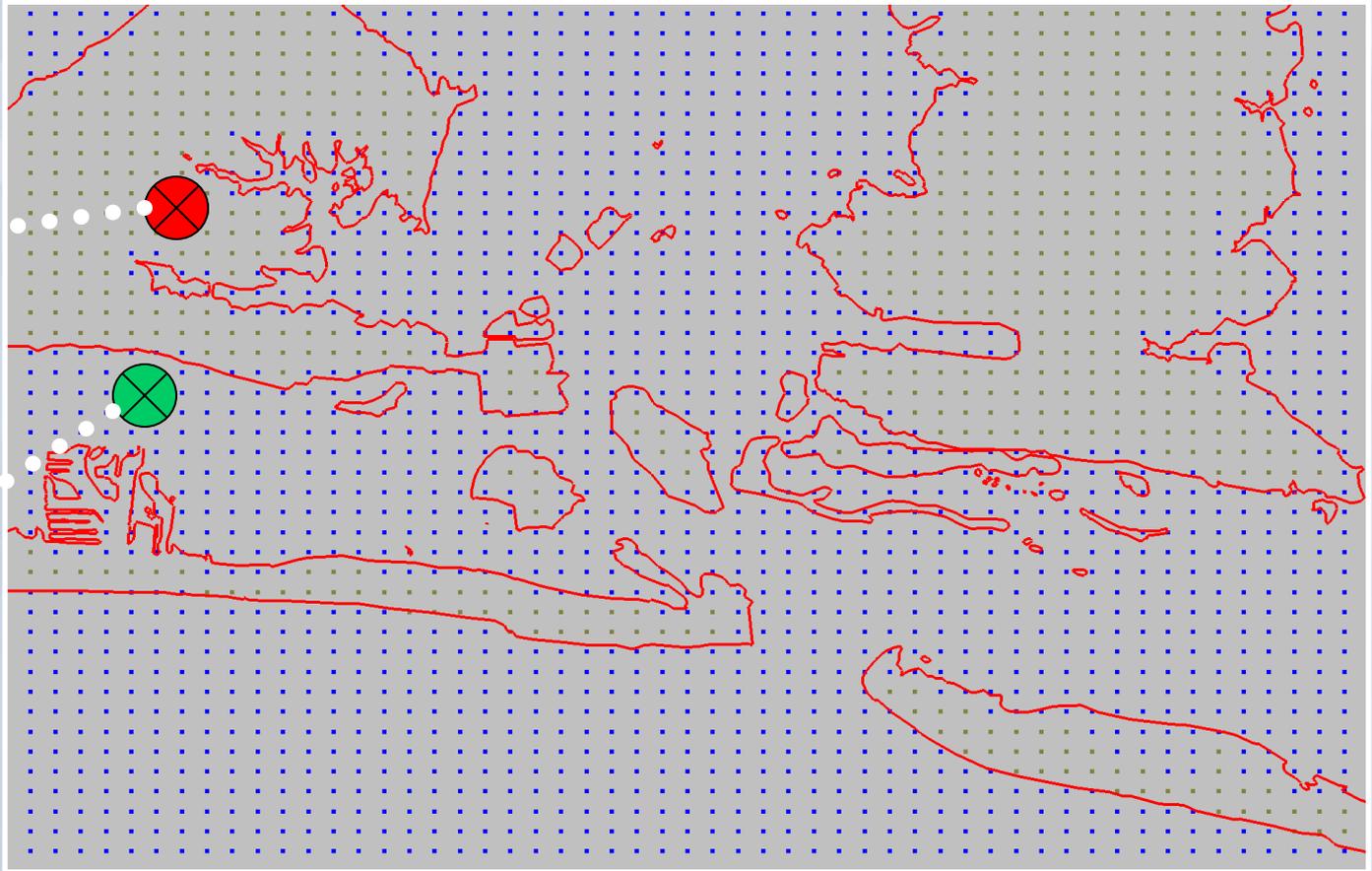
Append results to the end of the point record

Convert



Returned null
value = -999999.0

Returned a valid
conversion value



- With exception of small buffer region near coastline, user-input points falling on “land” side of MHW shoreline are assigned a null value.
- Orthometric and ellipsoidal conversions may still be made at land points, as only conversions involving tidal datums will be invalid inland of the buffer zone along coastline.



Utilizing VDatum: Input

NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Source Datum: NAD83(2011/2007/CORS96/HARN) - North... Target Datum: NAD83(2011/2007/CORS96/HARN) - North...

Source Coord. System: UTM (Easting, Northing) Target Coord. System: UTM (Easting, Northing)

Source Unit: meter (m) Target Unit: meter (m)

Source Zone: 18 Target Zone: 18

Vertical Information

Source Datum: NAD83(2011/2007/CORS96/HARN) - North... Target Datum: MHW

Source Unit: meter (m) Target Unit: meter (m)

Source Height Sounding Target Height Sounding

GEOID model: Target GEOID model: GEOID12B

Point Conversion | ASCII File Conversion | **File Conversion**

File type: ASPRS LiDAR Data Exchange Format 1.0, 1.1 and 1.2

Use VDatum's File name(s): ESRI LiDAR Data Exchange Format 1.0, 1.1 and 1.2

File name(s): ESRI ASCII Raster Format

File name(s): ESRI Shapefile Vector Format

Save as:

Excluding NODATA points (points with coors. = -999999)

Convert

File Name: ARRA-LFTNE_Maine_2010_06454966_utm.las
File Size: 137,992 kb
File Date: Thu Feb 21 10:57:06 2013

File Type: LAS
File Signature: LASF
File Source ID: 0
Global Encoding: 0
LAS Version: 1.2

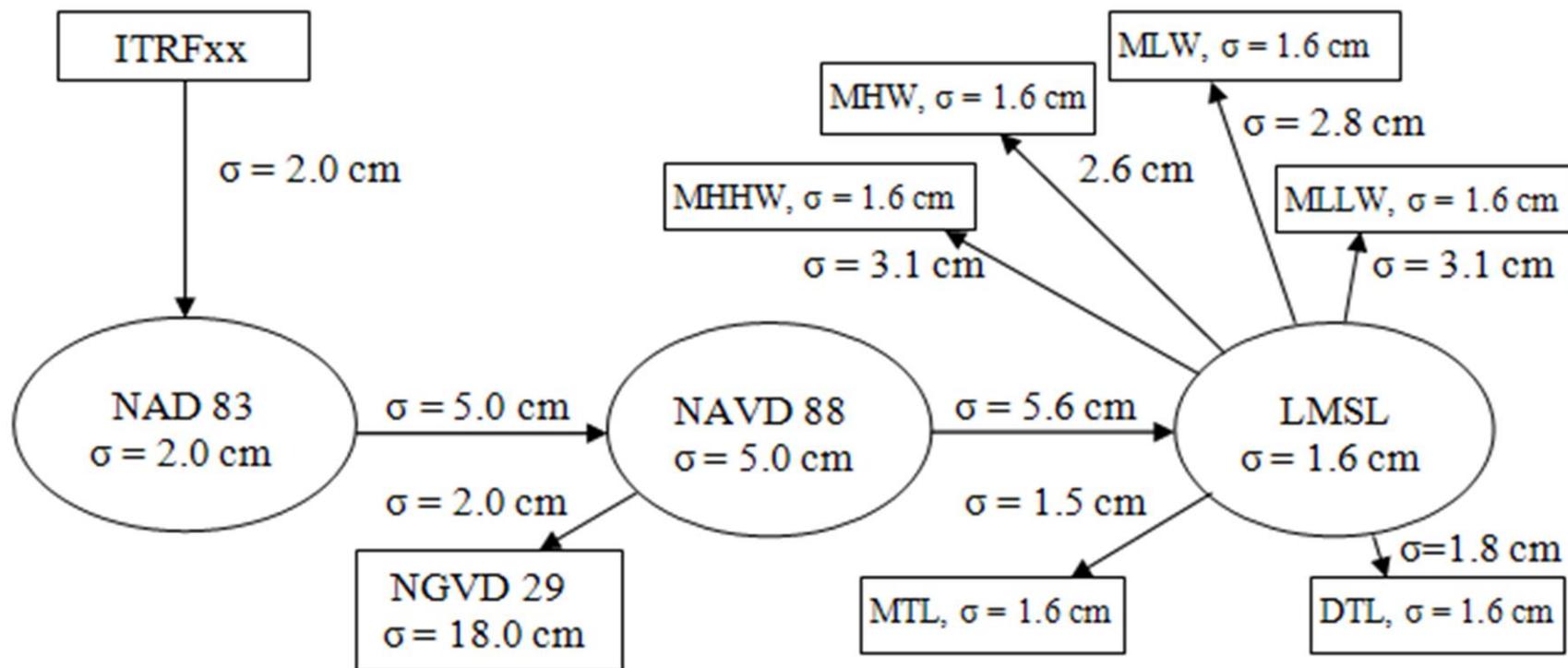
System Identifier: vdatum.noaa.gov
Generating Software: vdatum 3.2
File Creation Date: February 24, 2012
Per-point Time: YES
Per-point RGB: NO

Georegistration

Coordinate System: NAD83 / UTM zone 19N
Vertical Citation: vert: MHW:m:height
Horizontal Units: Meters
Vertical Units: Meters



VDatum Uncertainty Modeling



See: vdatum.noaa.gov/docs/est_uncertainties.html



VDatum Uncertainty Modeling (cm)

(ITRFxx to the tidal datum, the transformation with the greatest uncertainty)

VDATUM REGION	MAXIMUM CUMULATIVE UNCERTAINTY
California - Southern California from Morro Bay south to US/Mexico border	8.1
California - Monterey Bay to Morro Bay	8.0
California - San Francisco Bay Vicinity	9.8
Oregon/ California – Punta Gorda to Cape Blanco	13.1

Uncertainties that are constant for all VDatum regions of the U.S.

TRANSFORMATION			SOURCE DATA		
ITRFx to NAD83	NAD83 to NAVD88	NAVD88 to NGVD29	NAD83	NAVD88	NGVD29
2.0	5.0	2.0	2.0	5.0	18.0

REGION	TRANSFORMATION							SOURCE DATA	MCU
	NAVD88 to MSL	MSL to MHHW	MSL to MHW	MSL to MTL	MSL to DTL	MSL to MLW	MSL to MLLW	All Tidal Datums	
California - Southern California from Morro Bay south to US/Mexico border	1.6	1.4	0.9	0.1	0.4	0.8	0.9	1.3	8.1
California - Monterey Bay to Morro Bay	1.1	0.8	1	0.7	1	0.9	1.7	1.1	8
California - San Francisco Bay Vicinity	0.1	3.7	4.5	2	2.5	4.2	5.8	1.4	9.8
Oregon/ California – Punta Gorda to Cape Blanco	4.4	2	1.6	2.5	4.4	5.7	9.5	1.2	13.1



Operational: Vertical Datum Transformation Uncertainty

```
20090721_47122H2102-works.las.log x
2016/06/01 13:10:30
NOAA's Vertical Datum Transformation v3.6

Coordinate System:      INPUT          OUTPUT
                       State Plane     State Plane
Horizontal Datum:      NAD83          NAD83
Horizontal Unit:       m                m
Zone:                  4601
Vertical Datum:        NAD83          NAVD88
Vertical Unit:         m                m
Height/Sounding:       height          height
GEOID model:          geoid12b        geoid12b
Vertical Area:         geoid12b
Vertical Uncertainty:  7.3485cm

From: C:\temp\las_files\las_files\20090721_47122H2102-works.las
To: C:\temp\las_files\las_files\result\20090721_47122H2102-works.las
Number of processed Points: 333773
Number of valid-transform Points: 333773
Number of points in this output file (NODATA points were excluded): 3
```

NOAA's Vertical Datum Transformation - v3.6.1

Horizontal Information

Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	NAD83(2011/2007/CORS96/HARN) - North...
Coord. System:	Geographic (Longitude, Latitude)	Coord. System:	Geographic (Longitude, Latitude)
Unit:		Unit:	
Zone:		Zone:	

Vertical Information

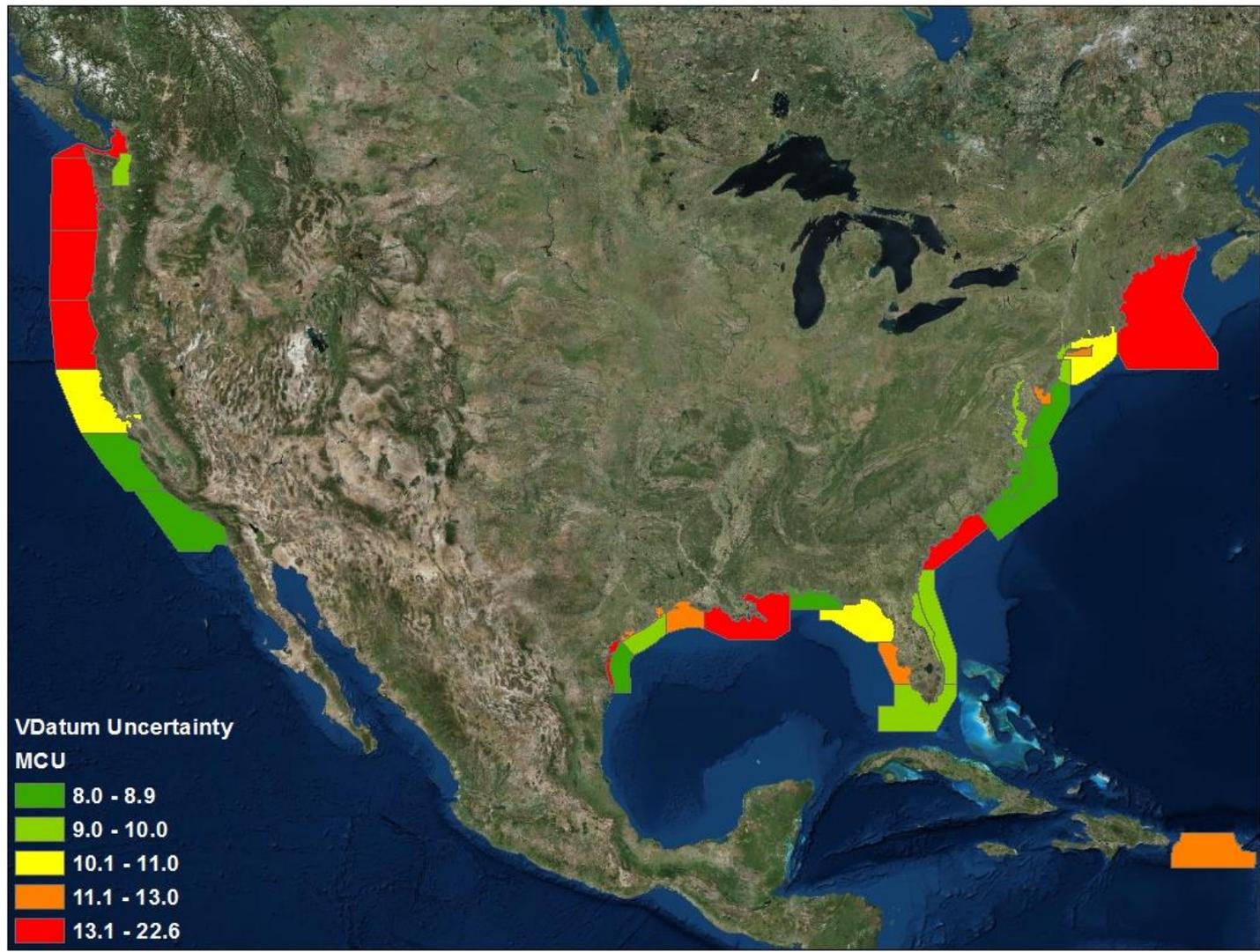
Source		Target	
Datum:	NAD83(2011/2007/CORS96/HARN) - North...	Datum:	MHW
Unit:	meter (m)	Unit:	meter (m)
<input checked="" type="radio"/> Height	<input type="radio"/> Sounding	<input checked="" type="radio"/> Height	<input type="radio"/> Sounding
<input type="checkbox"/> GEOID model:		<input checked="" type="checkbox"/> GEOID model:	GEOID12B

Point Conversion | ASCII File Conversion | File Conversion

Input		Output	
Longitude:	-77.818	Longitude:	-77.8180000
Latitude:	34.133	Latitude:	34.1330000
Height:	0	Height:	36.9576
Vertical_Area: NCcoast11_8301		Vertical Uncertainty: 9.5844cm	



Vertical Datum Uncertainties By Region



National Oceanic and Atmospheric Administration

What's Next: *Strategic Priorities*

- Reducing Regional Model Uncertainty to <10cm
- Increasing Coverage
- Spatially Varying Uncertainty
- Next Generation TSS Model (utilizing gravimetric GEOID transformation roadmap)
- Software Development
- Communication and Outreach



Foundational Data: Tidal



National Oceanic and Atmospheric Administration

NY/LIS Bight Gauging

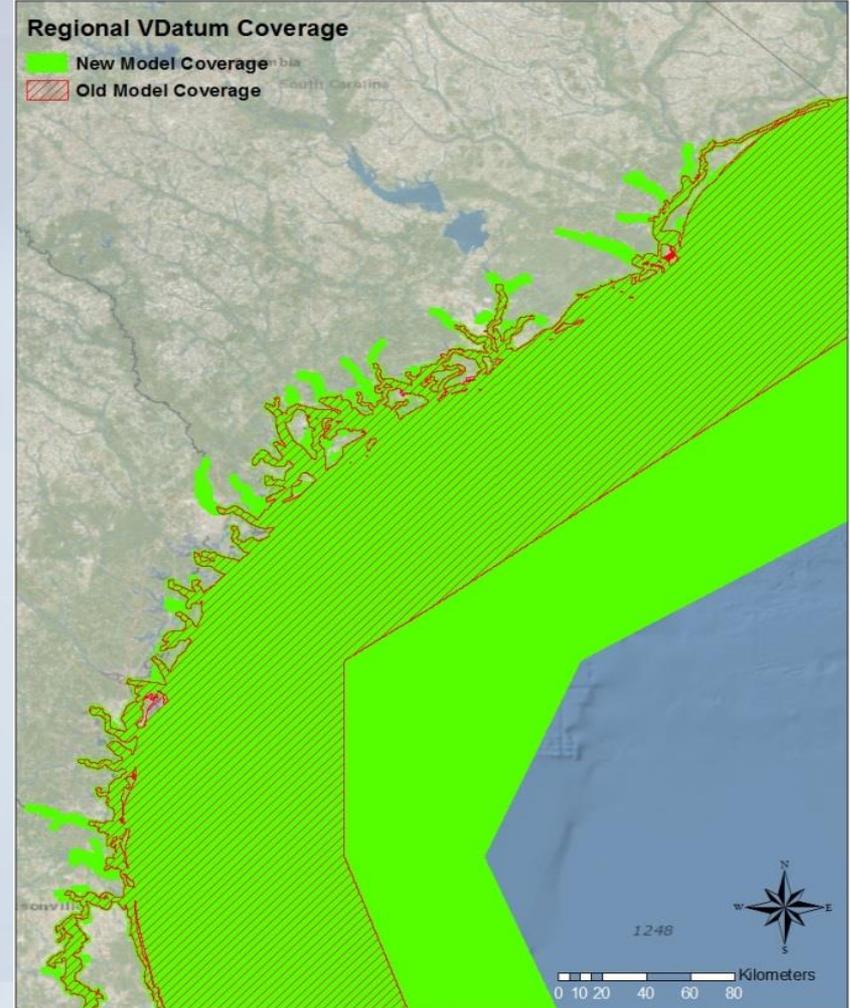
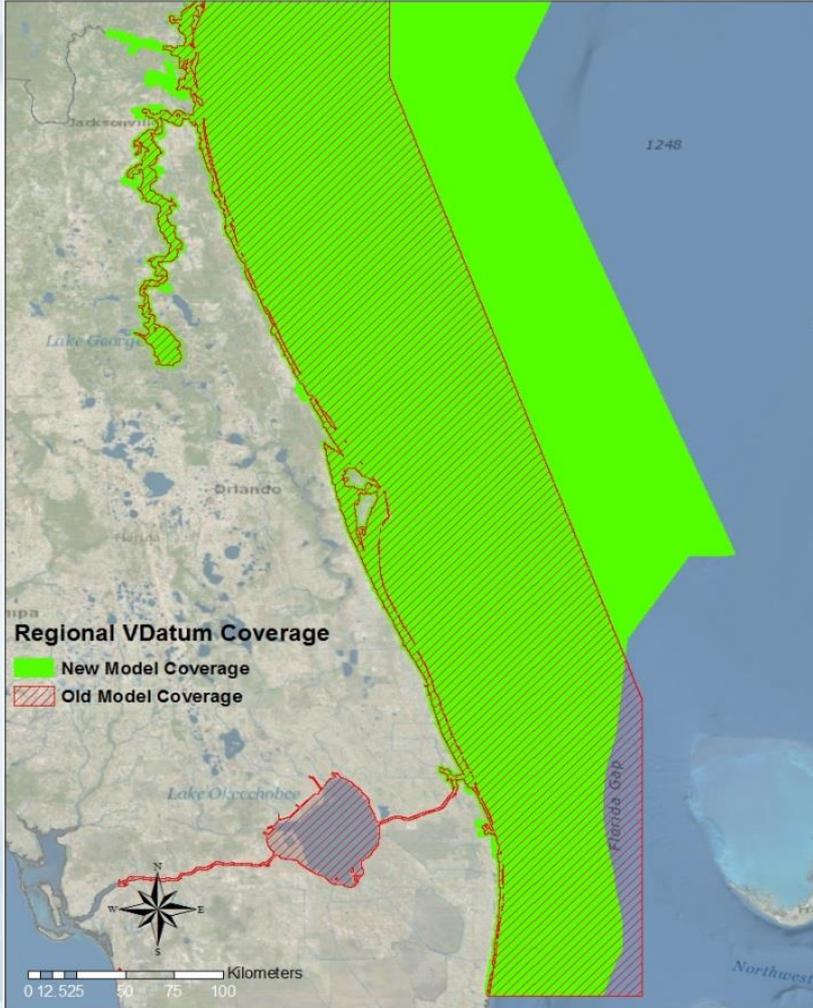
FY

△ 15

★ 16

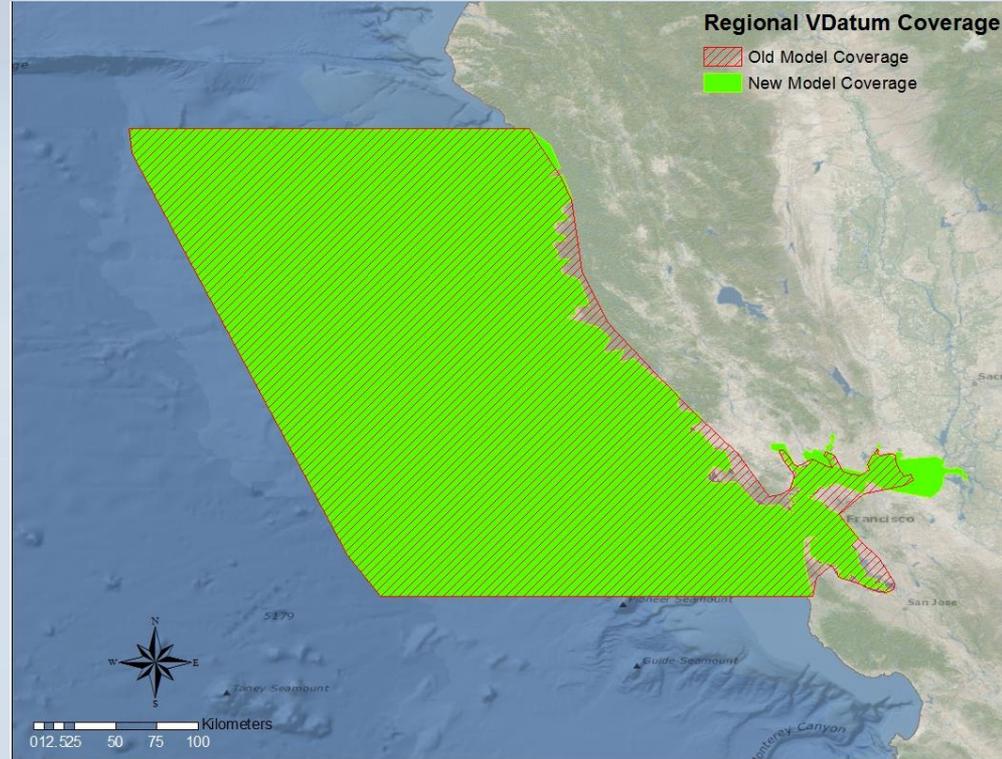
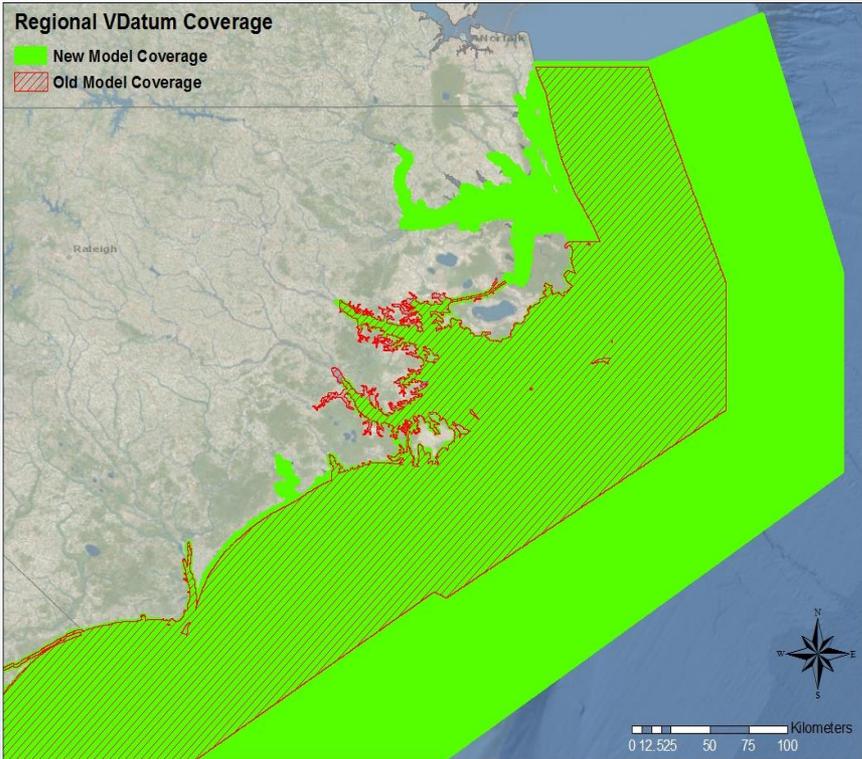
0 20 40 80 120 160 Kilometers

Increasing Spatial Coverage



National Oceanic and Atmospheric Administration

Increasing Spatial Coverage

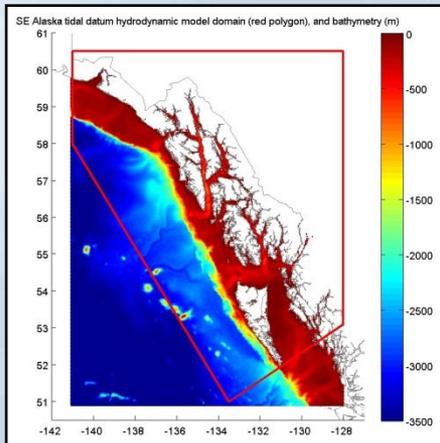
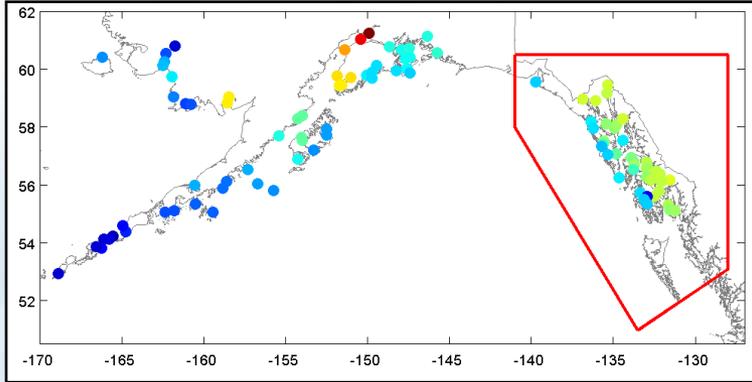


National Oceanic and Atmospheric Administration

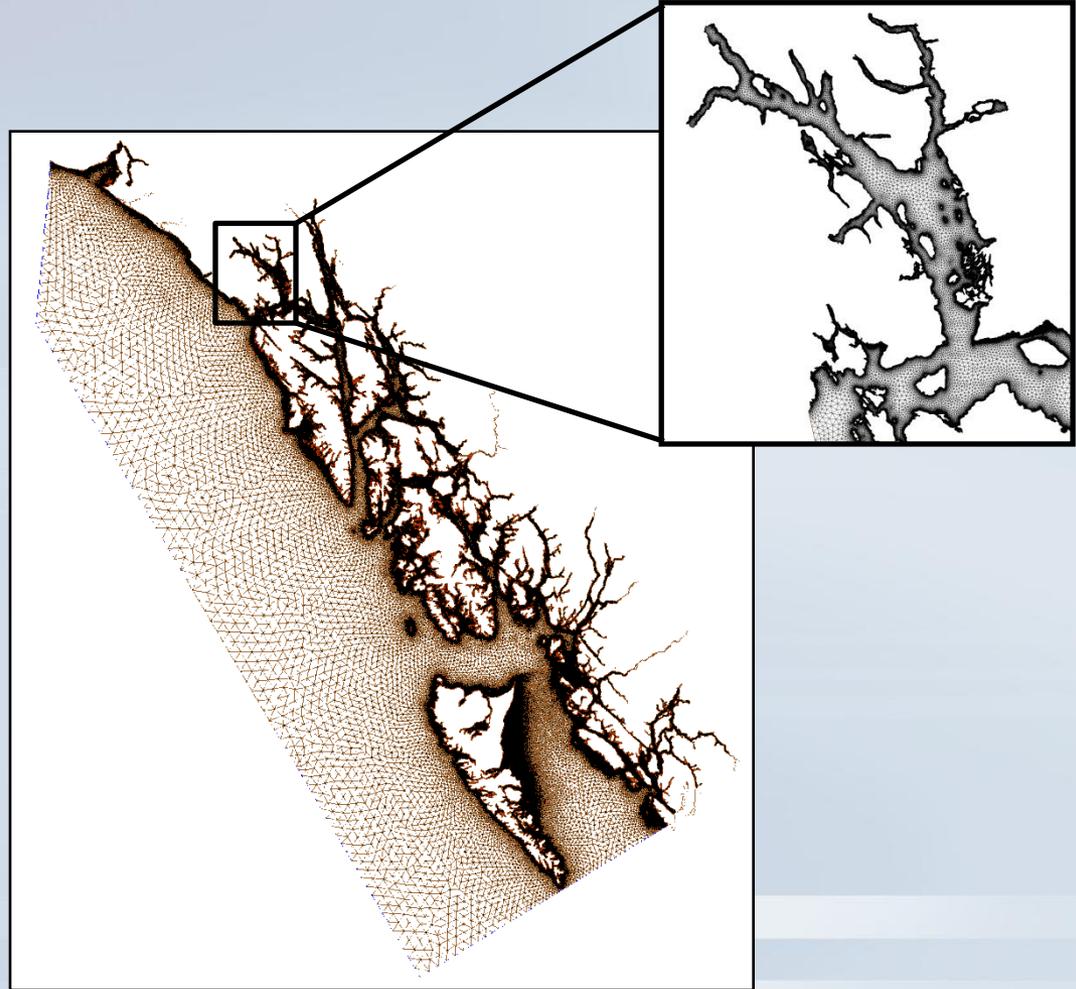
Exploratory Alaska Tidal Modeling

Southeast Alaska

Model Domain, Shoreline, and Tidal Data (M_2 amplitude shown in color)



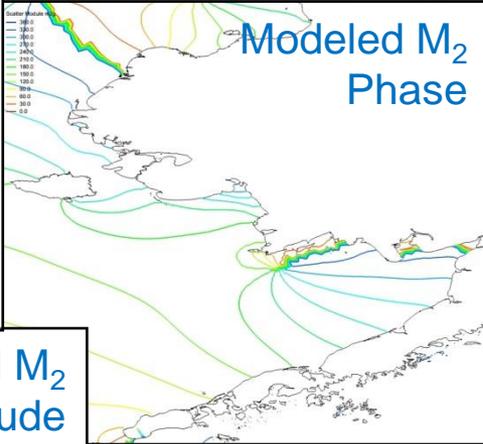
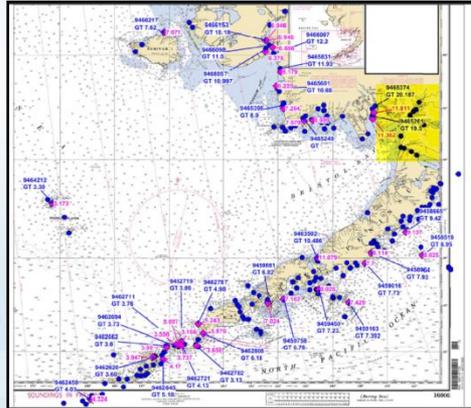
Bathymetry



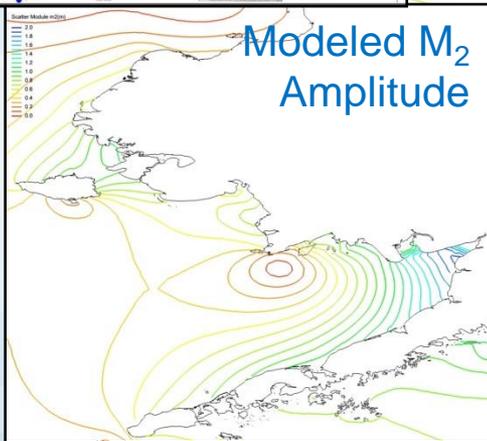
National Oceanic and Atmospheric Administration

Exploratory Alaska Tidal Modeling

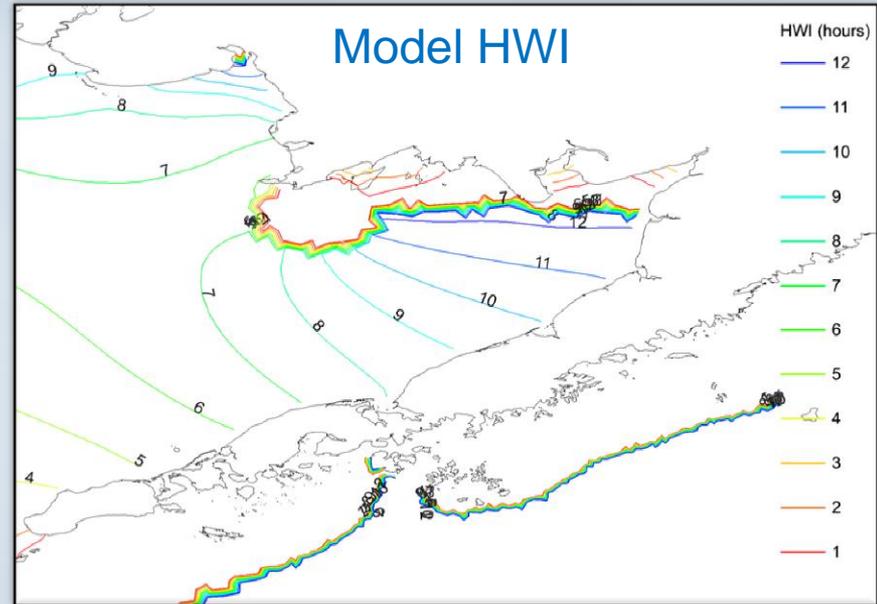
Western Alaska



Modeled M₂ Phase



Modeled M₂ Amplitude



Model HWI



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Future Enhancements:

Next Generation TSS

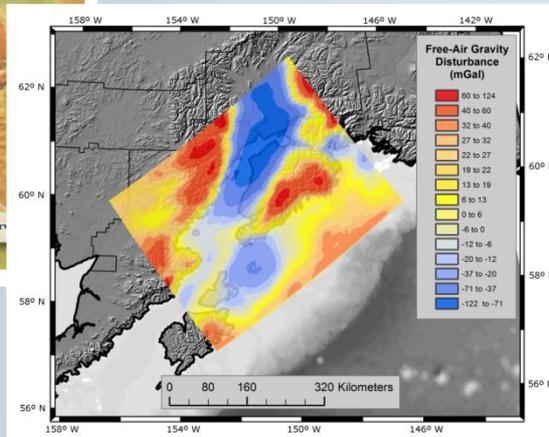
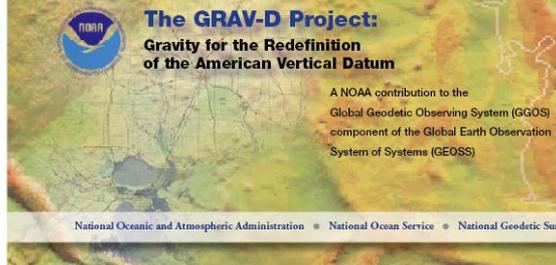


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GRAV-D: (Gravity for the Redefinition of the American* Vertical Datum)

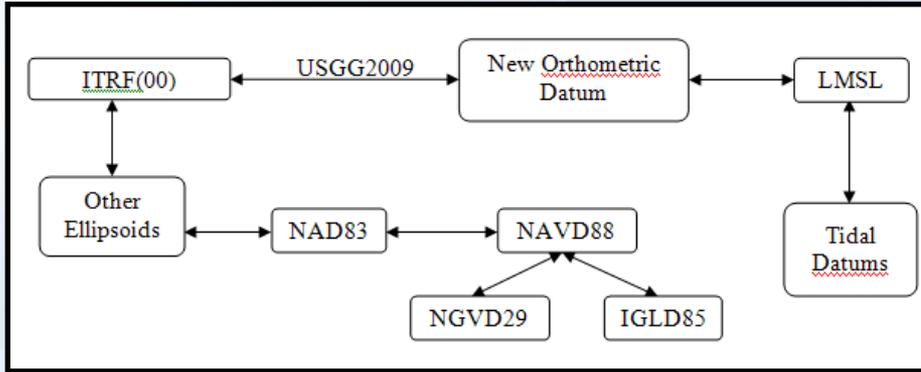


- An NGS project whose target is to redefine the official civilian vertical datum as the geoid, realized through the use of GNSS technology and a gravimetric geoid model over at least the United States and its territories
- *Official NGS policy as of Nov 14, 2007*
- *Re-define the Vertical Datum of the USA by 2022 (at current funding levels)*
- *Part of the NGS 10 year plan (2013-2023)*
- *Target: 2 cm accuracy orthometric heights from GNSS and a geoid model*

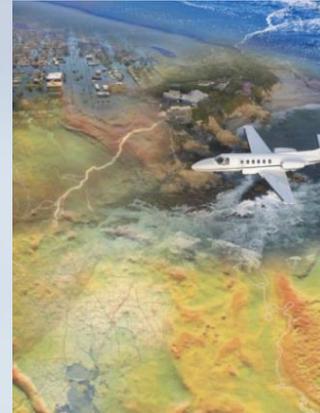


Future Enhancements: Next Generation TSS Development

New Proposed Transformation Roadmap based on a purely Gravimetric GEOID



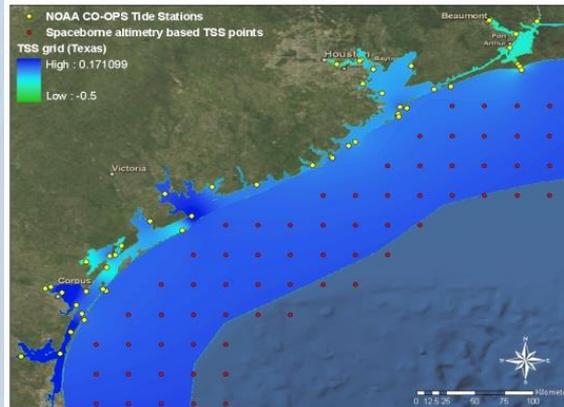
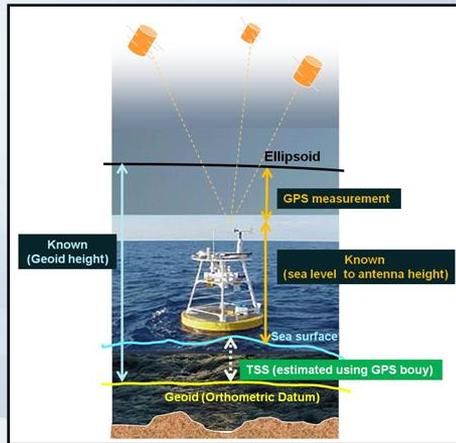
New GEOID: Coastal gravity field improvement



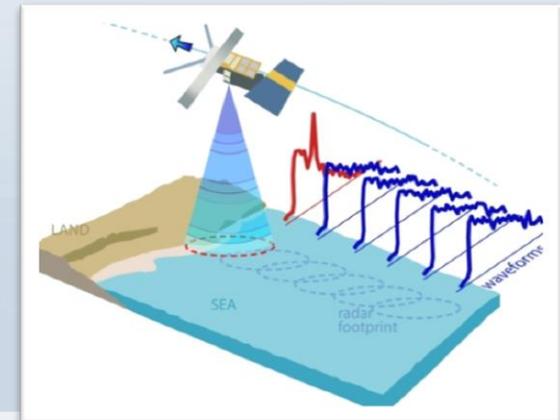
A Must: GPS Campaign on benchmarks to determine new relationships



Wish List: GPS tide buoys to be utilized for data input and validation



Satellite Altimetry/Derived Products to better understand offshore TSS

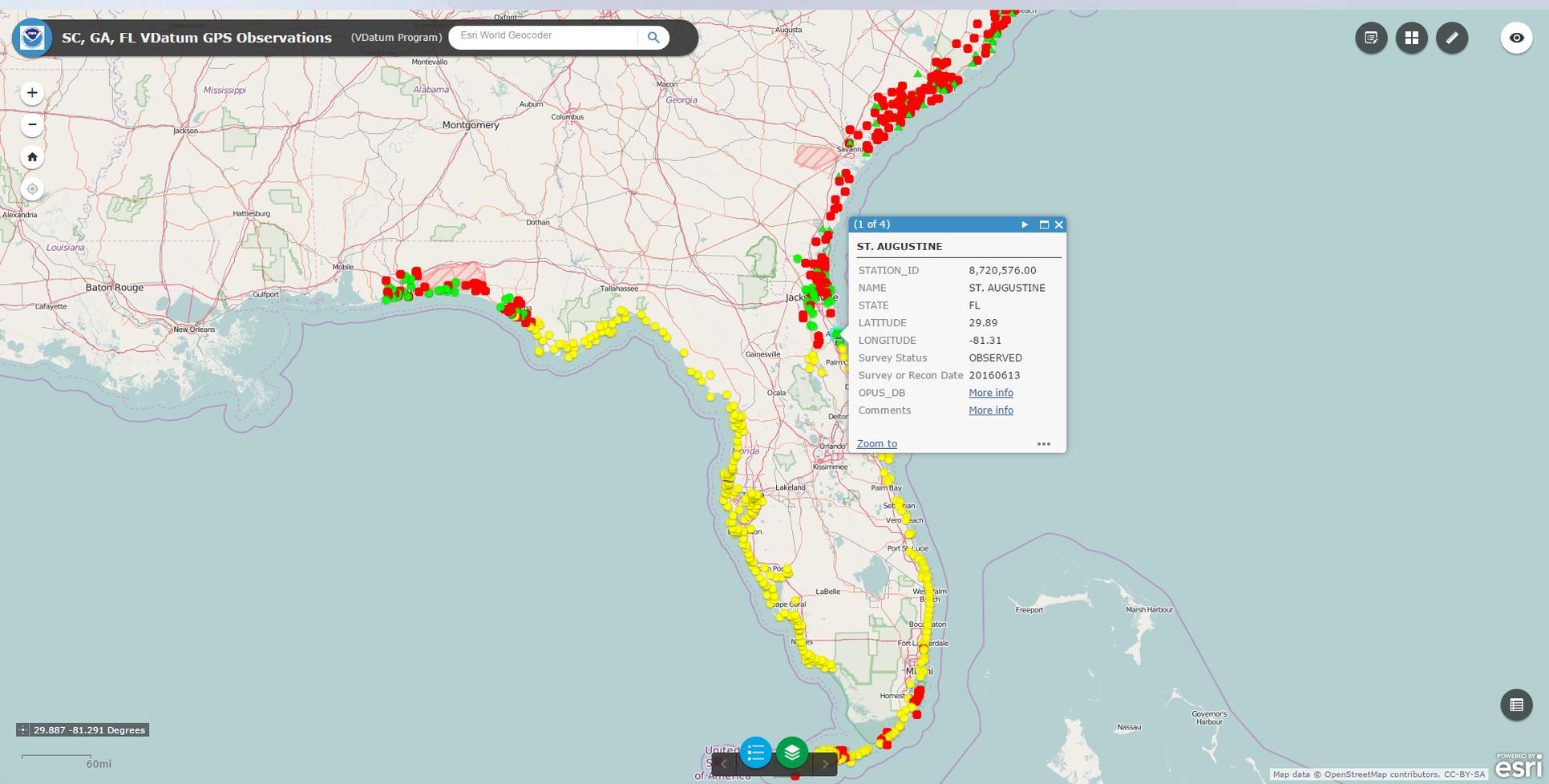


Re-tracked coastal altimetry data to capture nearshore sea surface height signal



National Oceanic and Atmospheric Administration

Foundational Data: Geodetic



National Oceanic and Atmospheric Administration

Foundational Data: Geodetic

Shared Solution

PID: AL6199
Designation: 872 6907 TIDAL 2
Stamping: NO II
Stability: May hold commonly subject to ground movement
Setting: Set in top of concrete monument
Mark: G
Condition: G
Description: The bench mark is a disk set in the top of a concrete monument, 3.66 m (12.0 ft) SW of the SW corner of the Bradley's two story frame house, located at the inside corner of sidewalk, below the grass.
Observed: 2016-02-06T16:08:00Z
Source: OPUS - page5 1209.04 [See Also 1983](#)



Close-up View

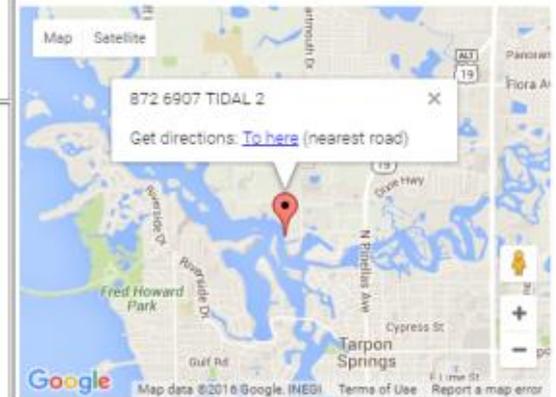
REF FRAME: NAD_83(2011)	EPOCH: 2010.0000	SOURCE: NAVD83 (Computed using GEOID12B)	UNITS: m	SET PROFILE	DETAILS
LAT: 28° 9' 34.27151" = 0.012 m LON: -82° 46' 1.76794" = 0.005 m ELL HT: -23.168 = 0.022 m X: 708497.621 = 0.008 m Y: -5582599.630 = 0.024 m Z: 2992091.614 = 0.005 m ORTHO HT: 1.952 = 0.040 m		UTM 17 SPC 902(FL W) NORTHING: 3116136.435m 424124.109m EASTING: 326489.766m 124655.519m CONVERGENCE: -0.83418006° -0.36206031° POINT SCALE: 0.99997158 1.00001121 COMBINED FACTOR: 0.99997522 1.00001485			

CONTRIBUTED BY

[stephen a white](#)
 National Geodetic Survey



Horizon View

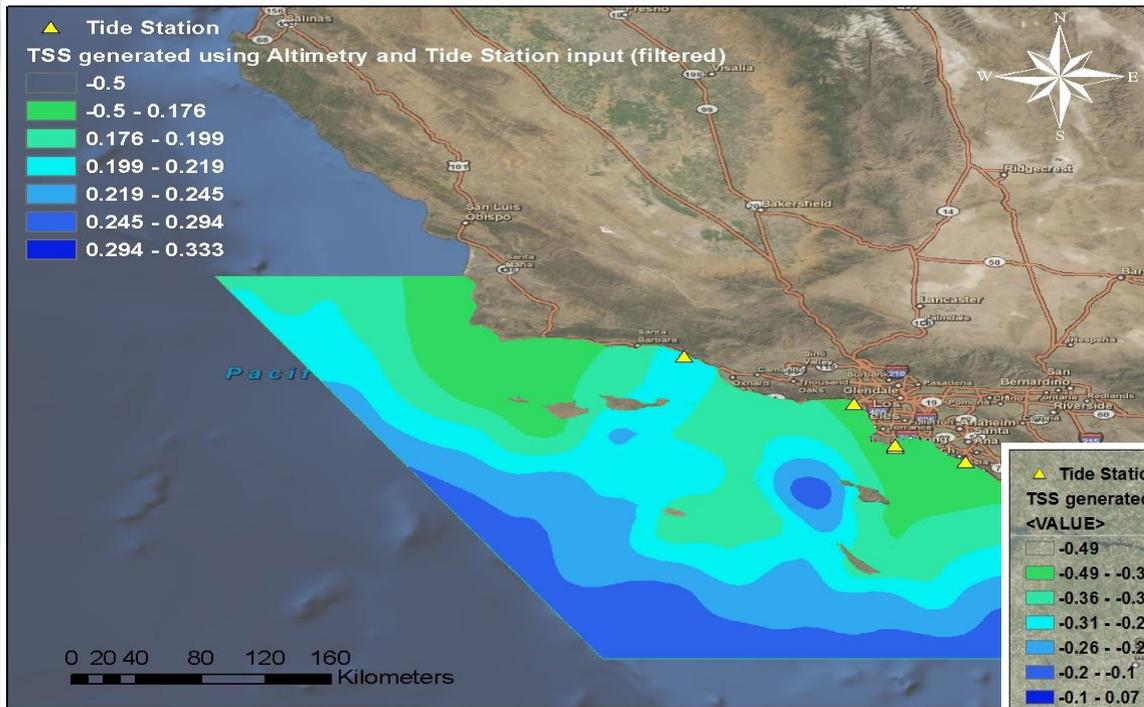


The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information is accurate.

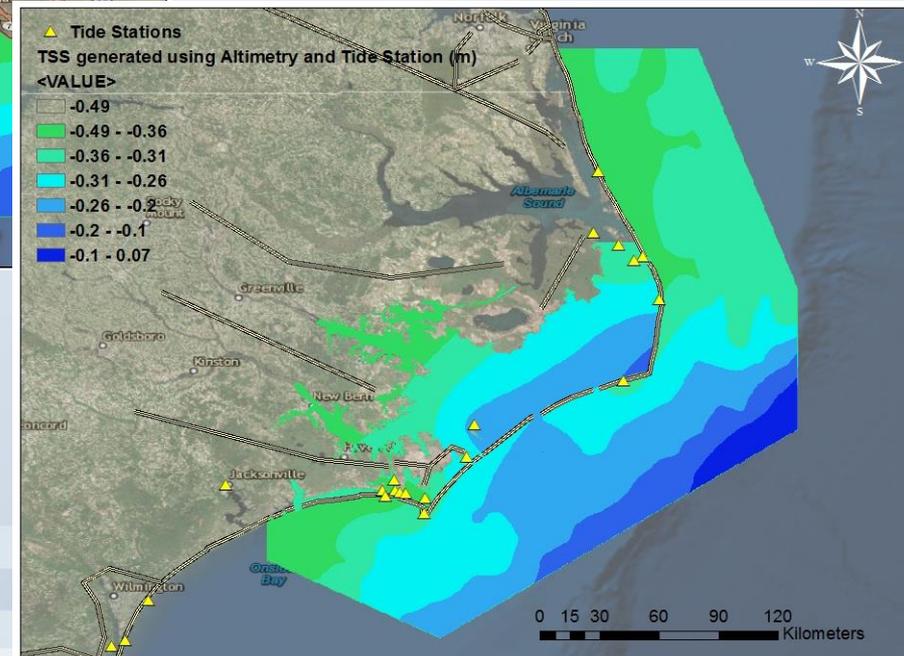


National Oceanic and Atmospheric Administration

Future Enhancements: Next Generation TSS Development



Refined TSS grid created using the derived TSS points at CNES MSS points (Gaussian filtered), and newly determined geodetic relationships at tide stations



Future Enhancements:

Spatially Variable Uncertainty (SVU) Estimation



National Oceanic and Atmospheric Administration

Spatially Varying Uncertainty: Topography of the Sea Surface

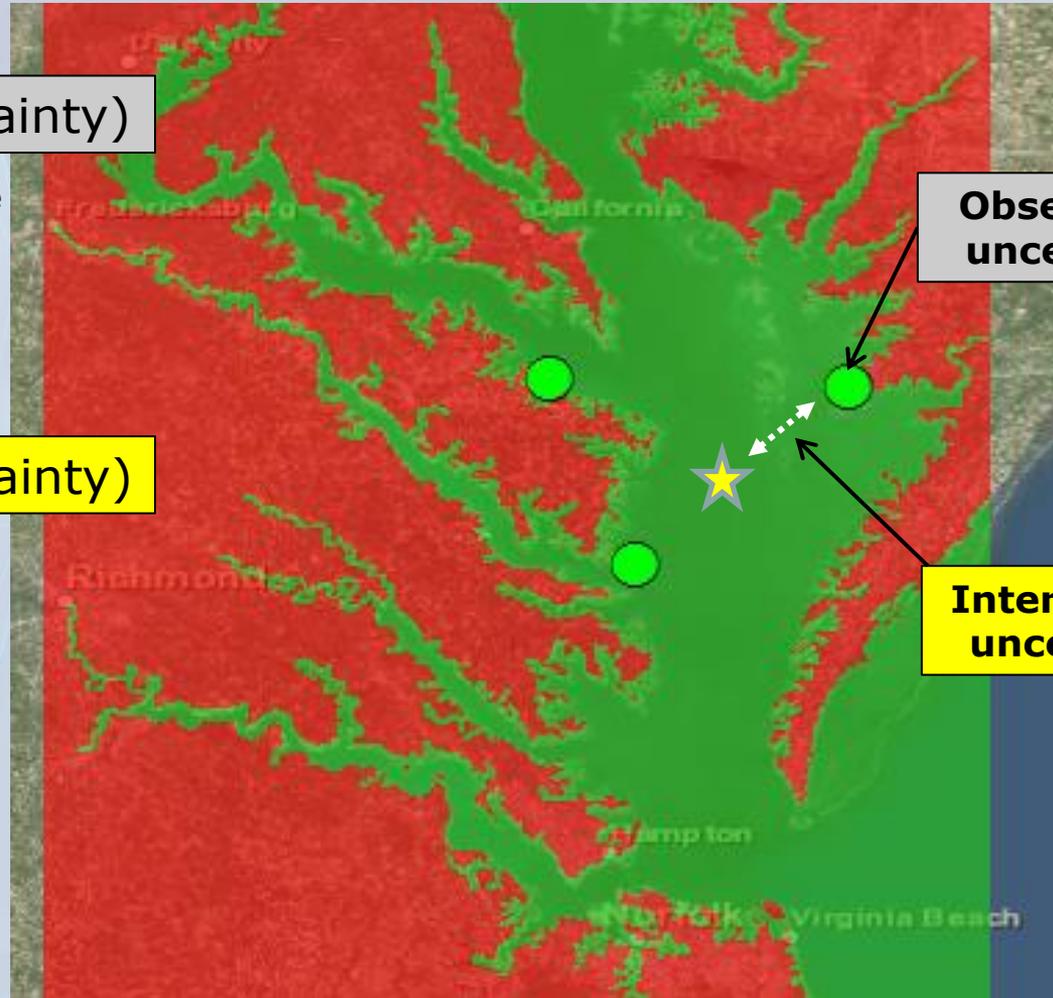
OU (Observation Uncertainty)

- given TSS uncertainty at tide gauge



IU (Interpolation Uncertainty)

- related to the interpolation performance over distance



Observation uncertainty

Interpolation uncertainty



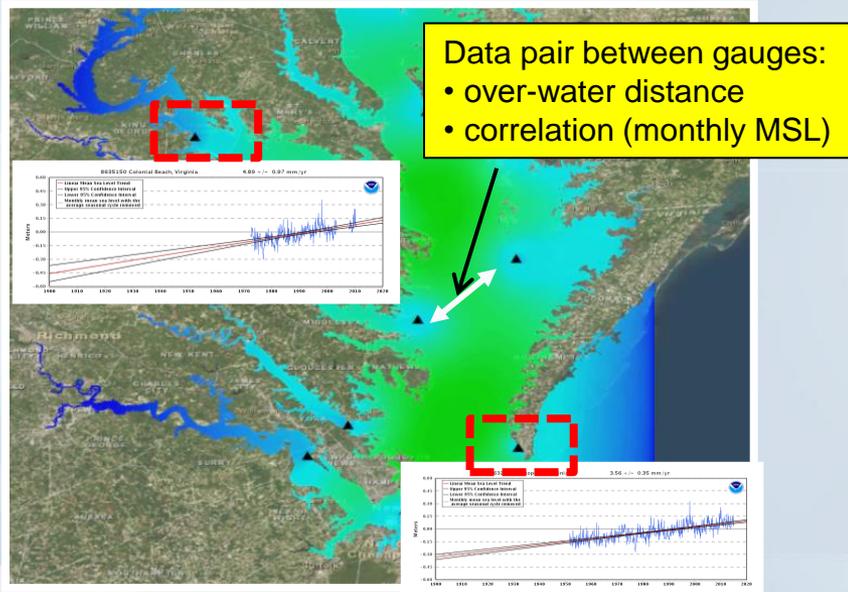
Spatially Varying Uncertainty: Topography of the Sea Surface

Rigorous Error Propagation

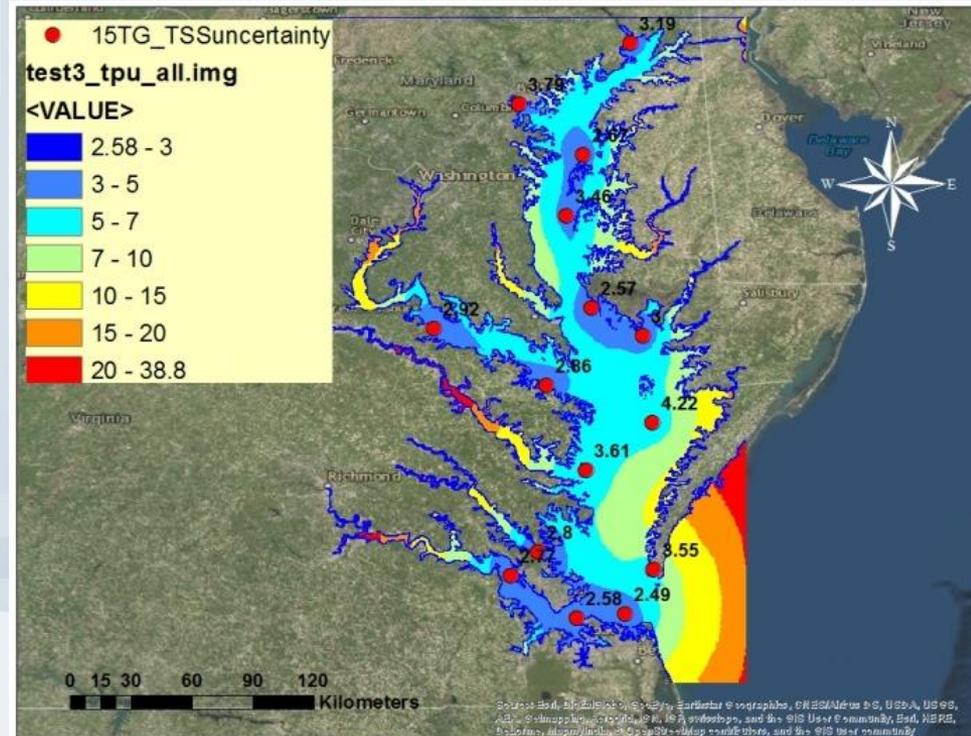
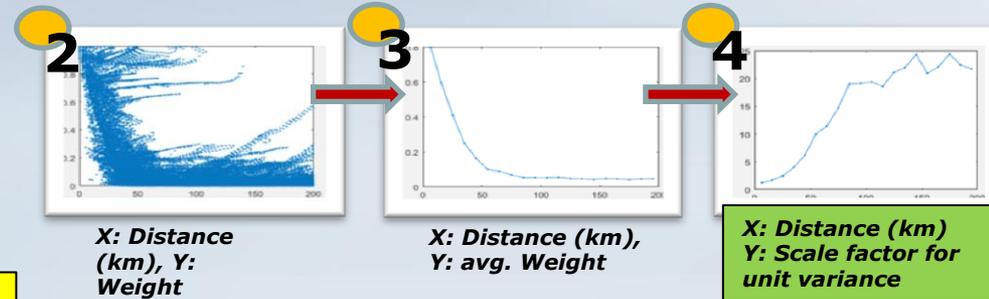
$$\Sigma_{TSS} = J_{TPU} \Sigma_{TSS\ obs} J_{TPU}^T + \Sigma_{Interpolation}$$

$$\Sigma_{TSS\ obs} = \begin{pmatrix} \sigma_1^2 & \dots & \sigma_{1,K} \\ \vdots & \ddots & \vdots \\ \sigma_{K,1} & \dots & \sigma_K^2 \end{pmatrix}$$

Deriving "Full" covariance matrix



Interpolation Uncertainty



National Oceanic and Atmospheric Administration

Source: Esri, DigitalGlobe, GeoEye, Earthstar, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, SIA, Airphoto, and the GIS User Community, Esri, HERE, DeLorme, Mapbox, Intel, Swire, and the GIS User Community

Spatially Varying Uncertainty: Tide Models

Table 2. The regression equations and parameters for estimating uncertainties in tidal datums for Mean Low Water (from Bodnar, 1981)

$$S1M = 0.0068 \text{ ADLWI} + 0.0053 \text{ SRGDIST} + 0.0302 \text{ MNR} + 0.029$$

$$S3M = 0.0043 \text{ ADLWI} + 0.0036 \text{ SRGDIST} + 0.0255 \text{ MNR} + 0.029$$

$$S6M = 0.0019 \text{ ADLWI} + 0.0023 \text{ SRGDIST} + 0.0207 \text{ MNR} + 0.030$$

$$S12M = 0.0045 \text{ SRSMN} + 0.128 \text{ MNR} + 0.025$$

Where:

S is the standard deviation (in feet),

M is the number of months of subordinate station observation,

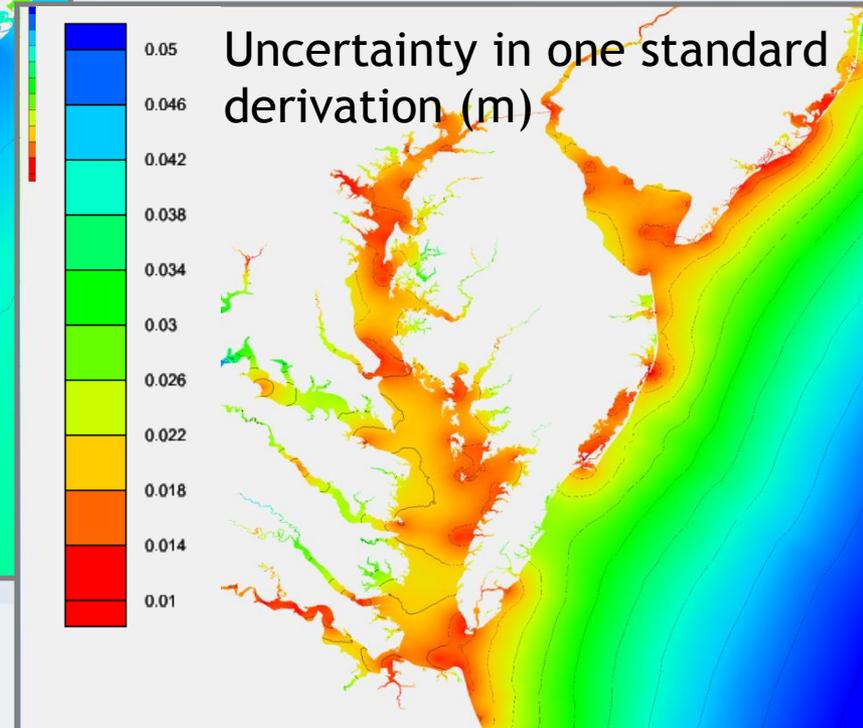
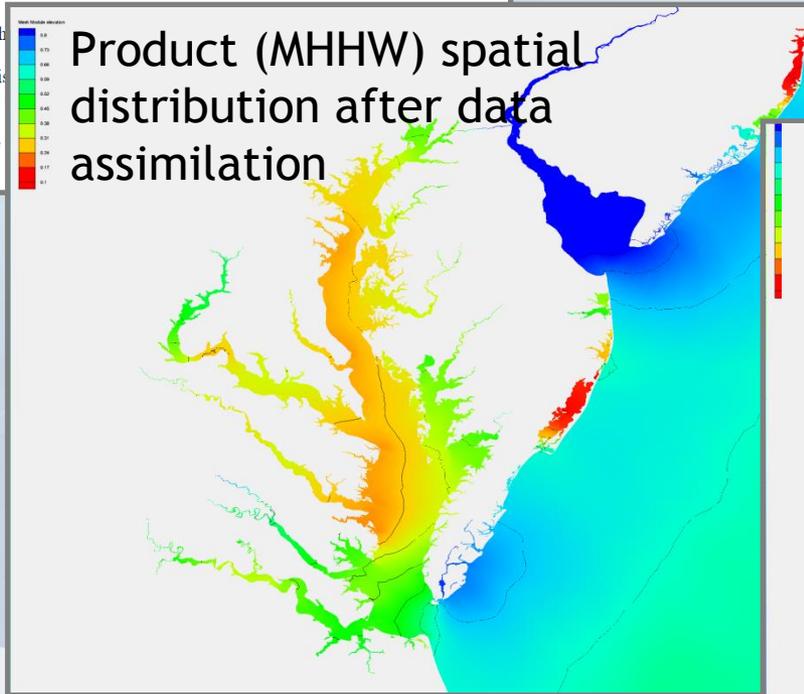
$ADLWI$ is the absolute time difference of the Low Water Intervals between control and subordinate stations (in hours),

$SRGDIST$ is the square root of the distance between control and subordinate stations (in nautical miles),

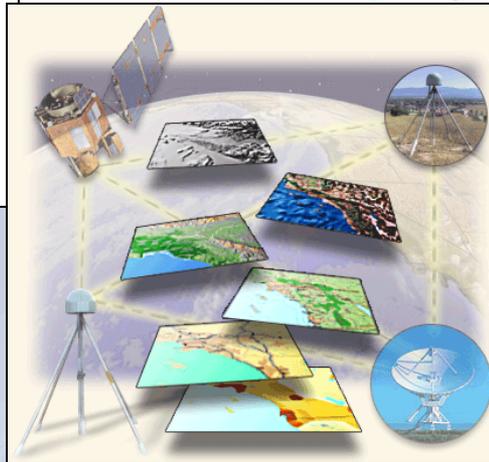
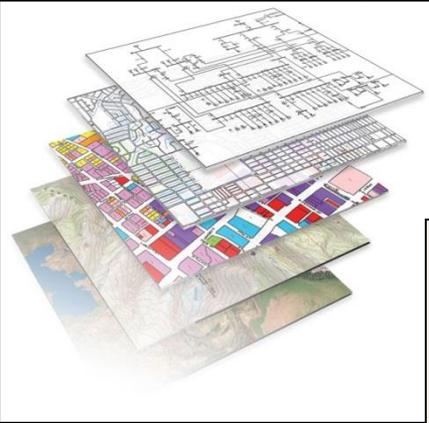
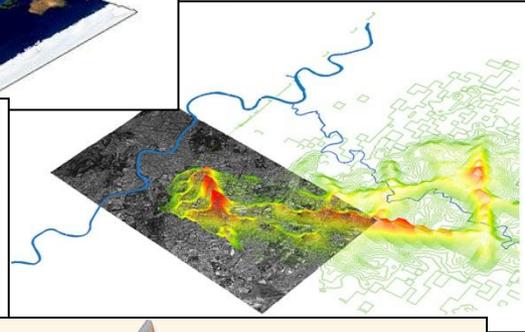
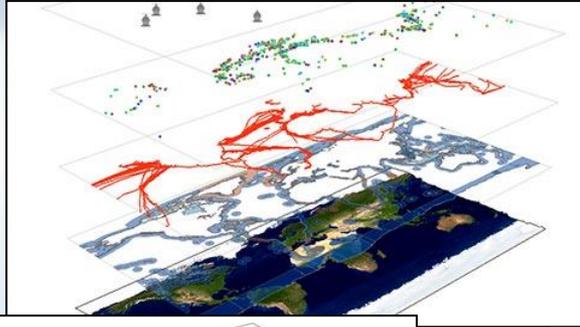
MNR is a mean range ratio that is calculated as the ratio of the range values between control and subordinate (using range values in feet), and

$SRSMN$ is the square root of the distance between control and subordinate (in feet).

- Statistical data assimilation is used to blend model results and data, also providing the associated uncertainty.
- Initial results for the Chesapeake Bay are shown below:



Software: Future Enhancements



- Bug Fixes
- Change Request
- GIS Format Support
 - GeoTiff
 - LAZ
 - LAS 1.3 and 1.4
- SVU Implementation
- Investigate integration of Gravimetric GEOID and new transformation roadmap
- Investigate integration of Next Generation TSS Grids
- Web Services (API?)
- **GeoCon, Time Dependency**



Production and Maintenance Schedule



-  New York / Long Island Sound (FY2018)
-  West Coast (FY2019)
-  Mid-Atlantic Bight (FY2022)

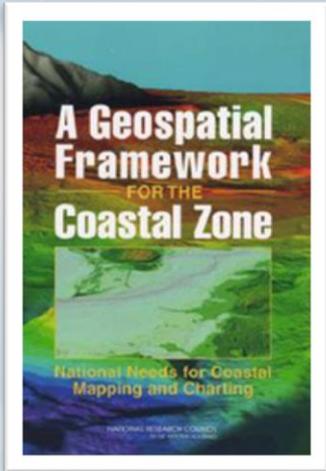


VDatum Applications



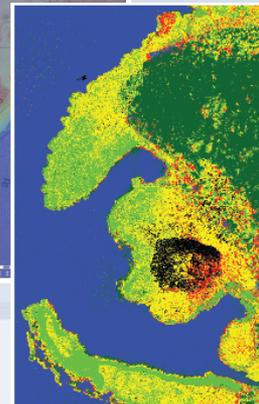
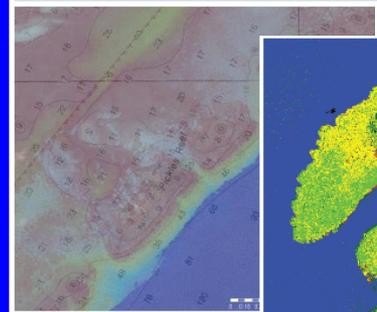
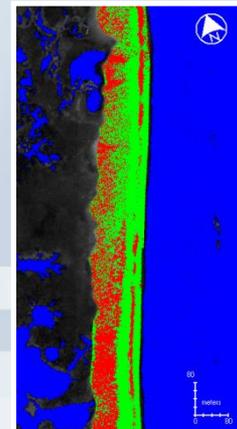
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Integrated Ocean and Coastal Mapping (IOCM)



The practice of acquiring, managing, integrating and disseminating ocean and coastal geospatial mapping data in such a manner that permits these data and their derivative products to be easily accessed and used by and for the greatest range of users and purposes.

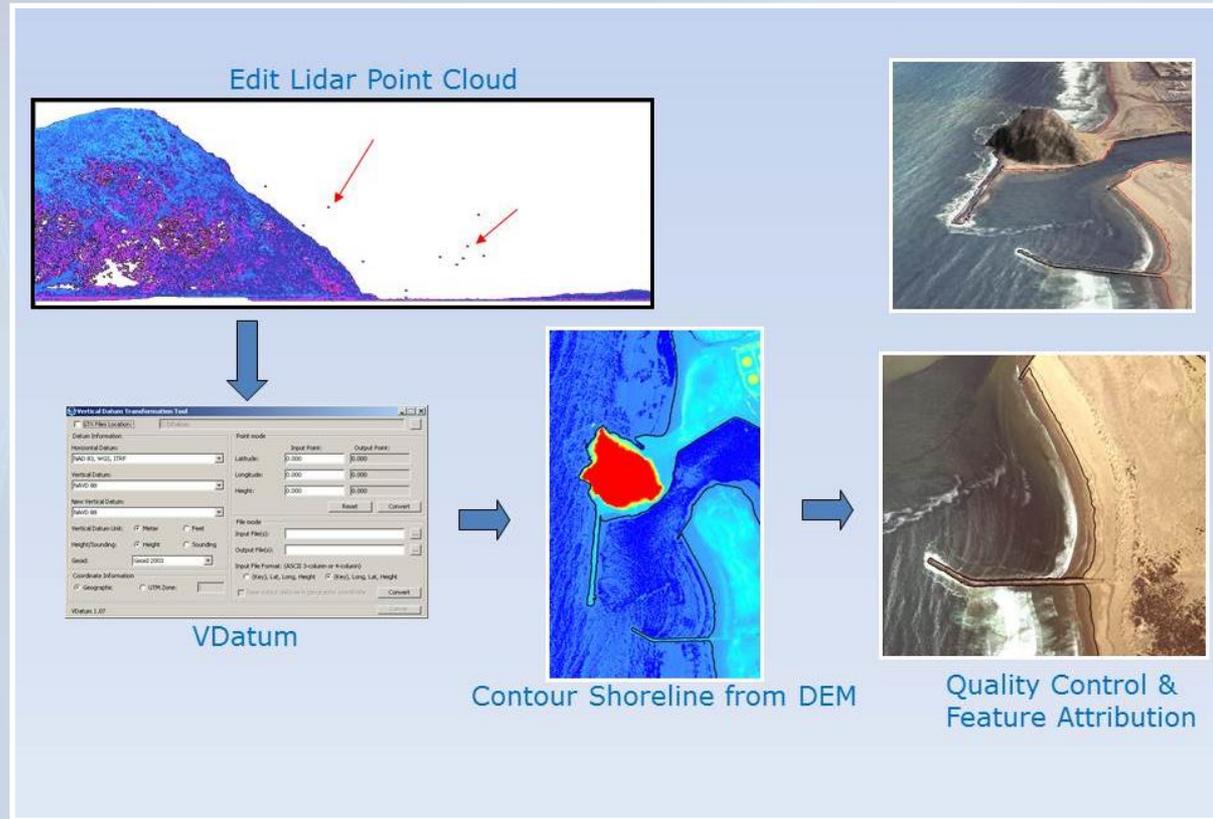
IOCM requires intra- and inter-agency coordination with a focus on streamlining operations, reducing redundancies, improving efficiencies, developing common standards, and stimulating innovation and technological development.



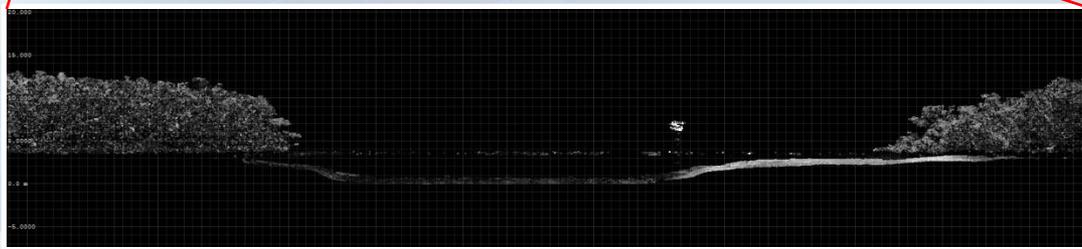
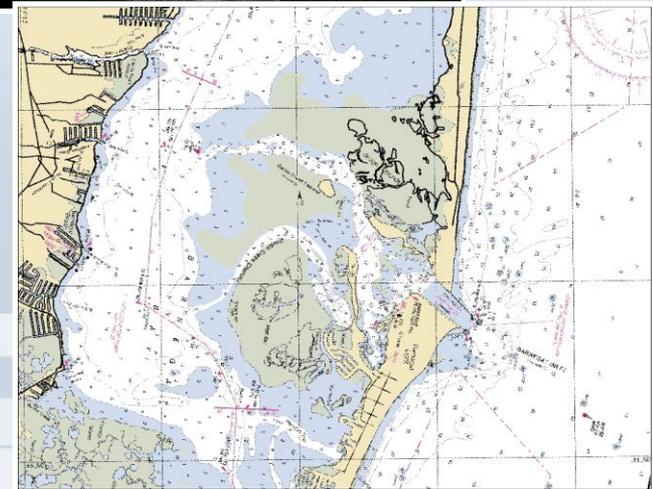
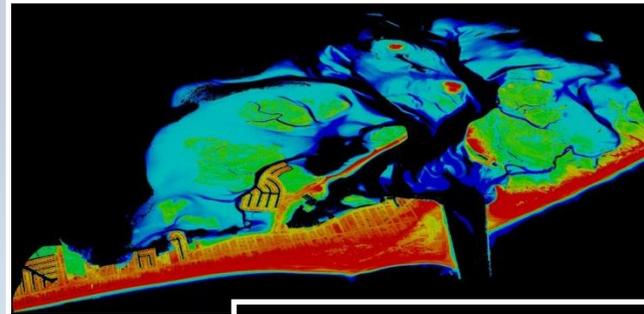
National Oceanic and Atmospheric Administration

Shoreline Extraction: A VDatum Charting Application

- Supports delineating the National Shoreline.
- Support of other applications:
 - NOAA nautical charts
 - Used in defining the United States' territorial limits
 - Coastal resource management
 - Storm surge and coastal flooding modeling
 - Coastal geomorphology studies
 - GIS analysis
 - Coastal Intelligence, Resiliency and Place-Based Conservation Applications



TopoBathy Lidar



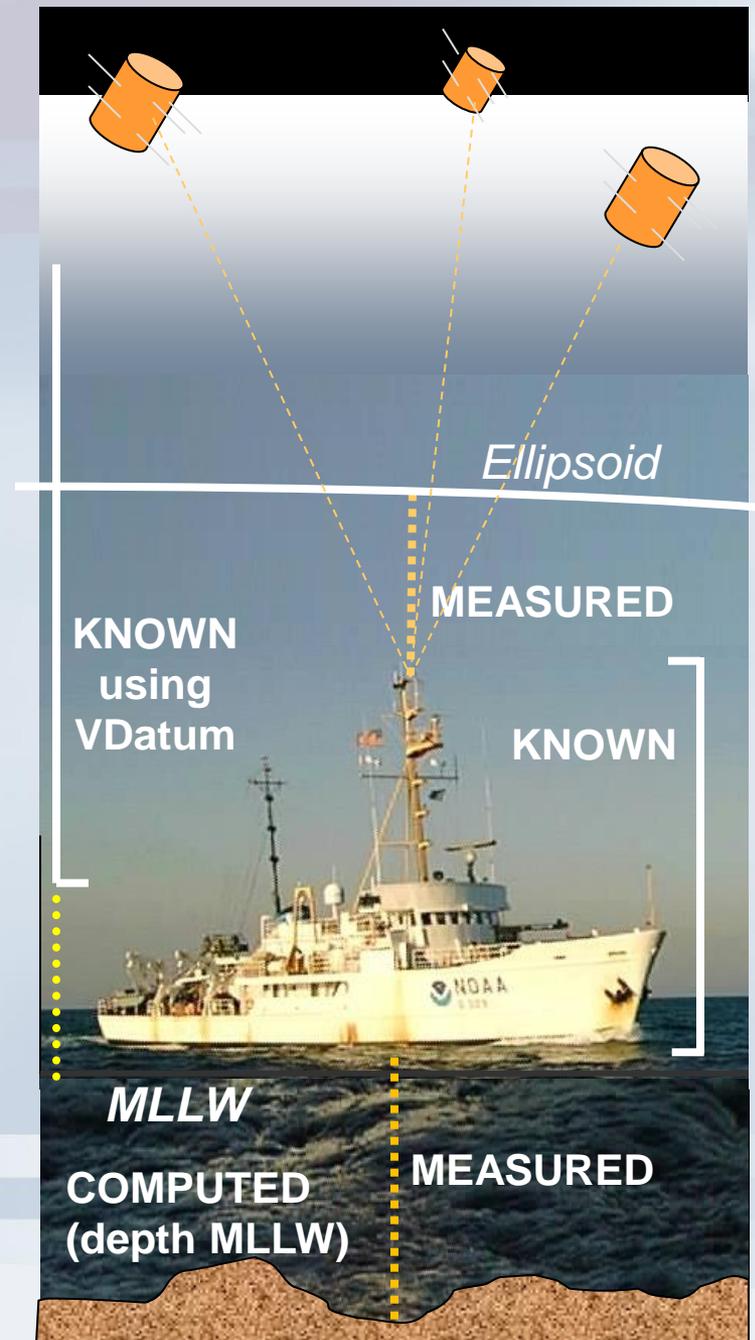
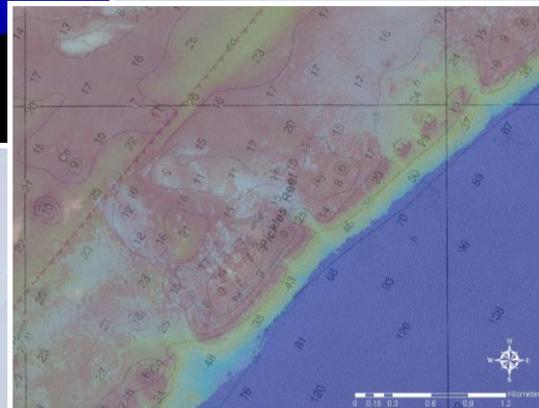
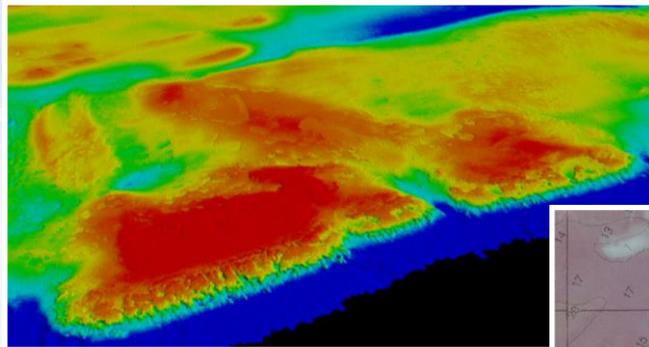
National Oceanic and Atmospheric Administration

Surveying on the Ellipsoid:

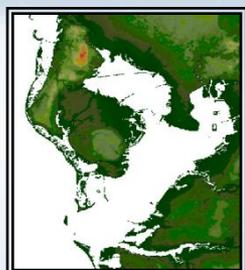
A VDatum Charting Application

Advantages:

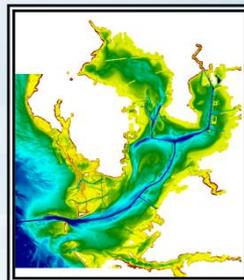
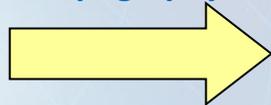
- Decouple tide measurement from survey
- Reduce vertical uncertainty from heave, dynamic draft



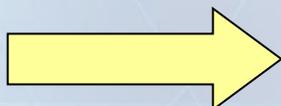
VDatum: Used to Create Digital Elevation Models



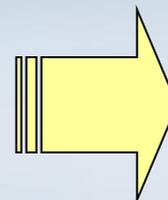
Topography



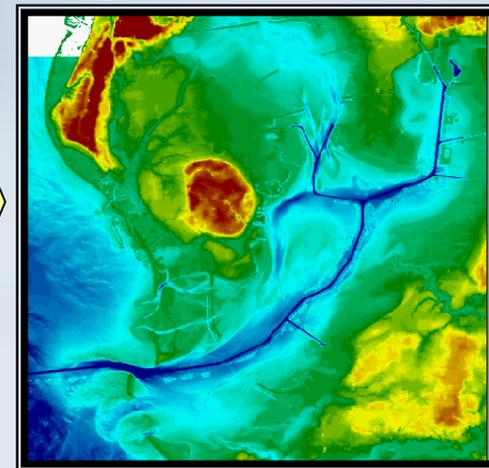
Bathymetry



VDatum



Topo/ Bathy
Digital Elevation Model



Applications for Seamless Bathy/Topo Datasets:

- Inundation modeling from storm surge, tsunamis, and sea level rise.
- Erosion, accretion, renourishment
- Analyzing storm impacts
- Determining setback lines
- Determining local, state, and national boundaries
- Navigation products and services
- Habitat restoration
- Shoreline Change Analysis
- Analyzing environmental and natural resources
- Permitting



National Oceanic and Atmospheric Administration

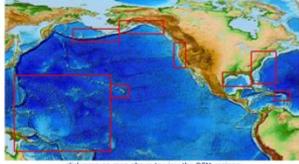
Utilizing VDatum for Digital Elevation Model Creation: Tsunami Inundation

NOAA NATIONAL GEOPHYSICAL DATA CENTER
U.S. DEPARTMENT OF COMMERCE

NOAA > NESDIS > NGDC > HGDD > Bathymetry & Relief

All Bathym/Topo Coastal DEM Portal Fishing Global Lakes Multibeam NOS surveys

NOAA Tsunami Inundation Digital Elevation Models (DEMs)



Click area on map above to view the DEM regions

Project contact:
[Lisa A. Taylor@noaa.gov](mailto:Lisa.A.Taylor@noaa.gov)
 phone: 303-497-6767

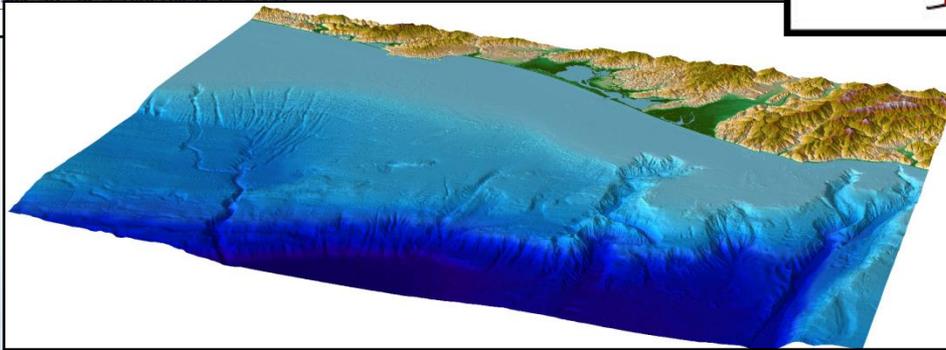
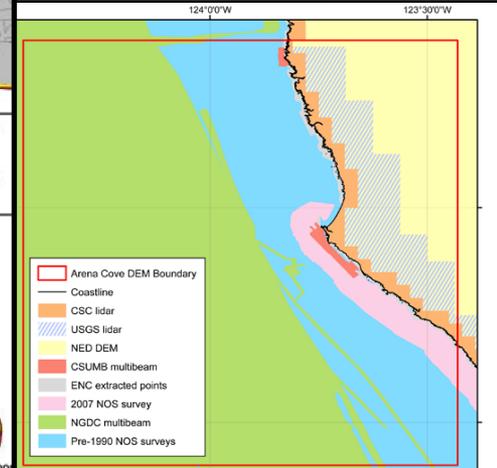
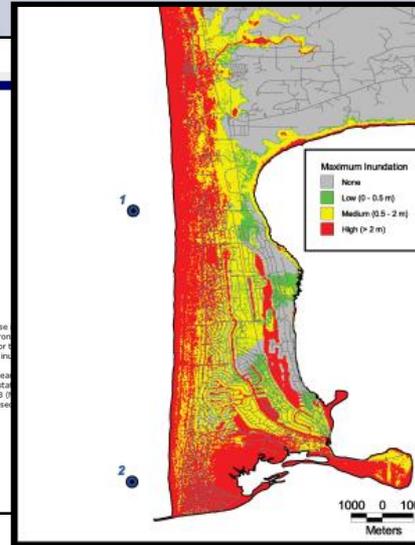
Technical contact:
[Barry Eskins@noaa.gov](mailto:Barry.Eskins@noaa.gov)
 phone: 303-497-6505

NOAA's National Geophysical Data Center (NGDC) is building high-resolution digital elevation models (DEMs) of select U.S. coastal regions. These topographic DEMs are used to support tsunami forecasting and modeling efforts at the NOAA Center for Tsunami Research, Pacific Marine Environment. The DEMs are part of the tsunami forecast system SIFT (Short-term Inundation Forecasting for Tsunamis) currently being developed by PMEL for the Centers, and are used in the [MOST \(Method of Splitting Tsunami\)](#) model developed by PMEL to simulate tsunami generation, propagation, and impact.

Bathymetric, topographic, and shoreline data used in DEM compilation are obtained from various sources, including NGDC, the U.S. National Oceanic and Atmospheric Administration (NOAA), the U.S. Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), and other federal, state agencies, academic institutions, and private companies. DEMs are referenced to a vertical tidal datum of North American Vertical Datum of 1988 (NAVD 88) and horizontal datum of World Geodetic System of 1984 (WGS 84). Cell size ranges from 1/3 arc-second (~10 meters) to 36 arc-seconds (~1000 meters).

NEW! DEMs built by the PMEL's NOAA Center for Tsunami Research are now available for download from this web site.

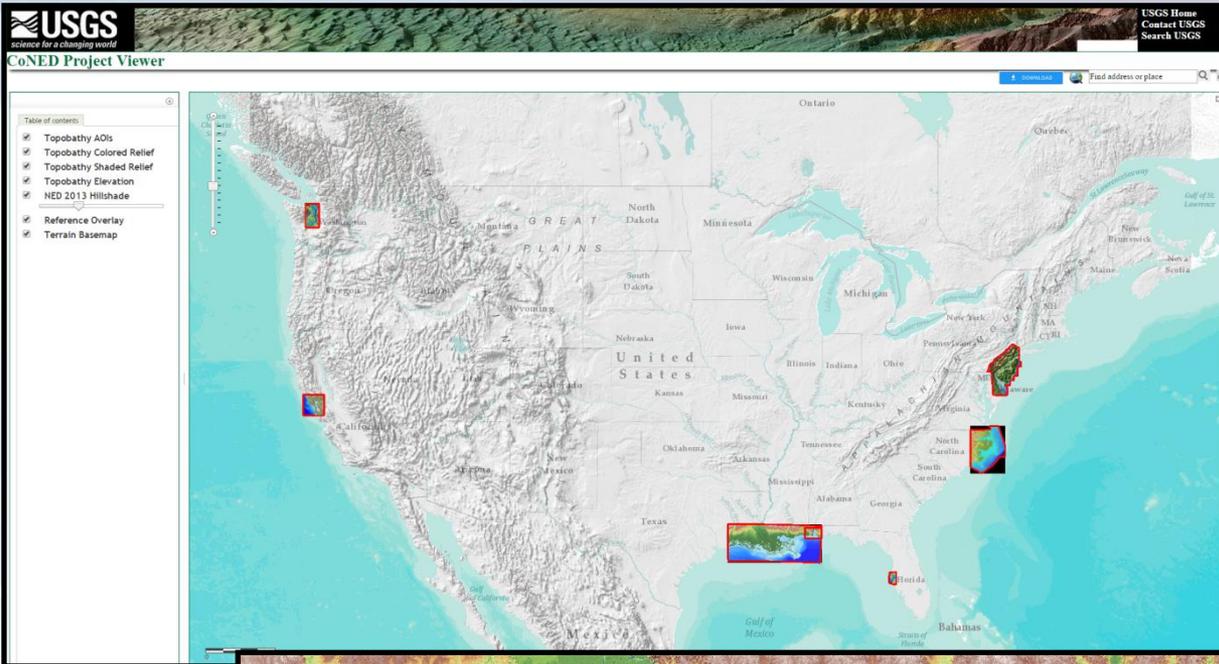
How to Cite DEMs:
 For each DEM, cite the accompanying DEM Development Report.



Source	Year	Data Type	Spatial Resolution	Original Horizontal Datum/Coordinate System	Original Vertical Datum
NGDC	1921 to 2008	NOS hydrographic survey soundings	Ranges from less than 10 m to 600 m (varies with scale of survey, depth, traffic, and probability of obstructions)	NAD 83 geographic	MLLW
NGDC	1984 to 2006	Multibeam swath sonar	gridded to 1 arc-second	WGS 84 geographic	Assumed Mean Sea Level
University of New Hampshire, Center for Coastal and Ocean Mapping, Joint Hydrographic Center	2009	Multibeam swath sonar	40 meter grid	WGS 84 geographic	Inferred Mean Sea Level
U.S. Army Corps of Engineers	2009	Hydrographic survey	Not Available	NAD 83 California State Plane I (feet)	MLLW
California State University Seafloor Mapping Laboratory	2005	Multibeam swath sonar	1 meter grid	WGS 84 UTM 10 North	NAVD 88
NOAA Office of Coast Survey	1992 to 2008	ENC extracted soundings	Not Available	WGS 84 geographic	MLLW

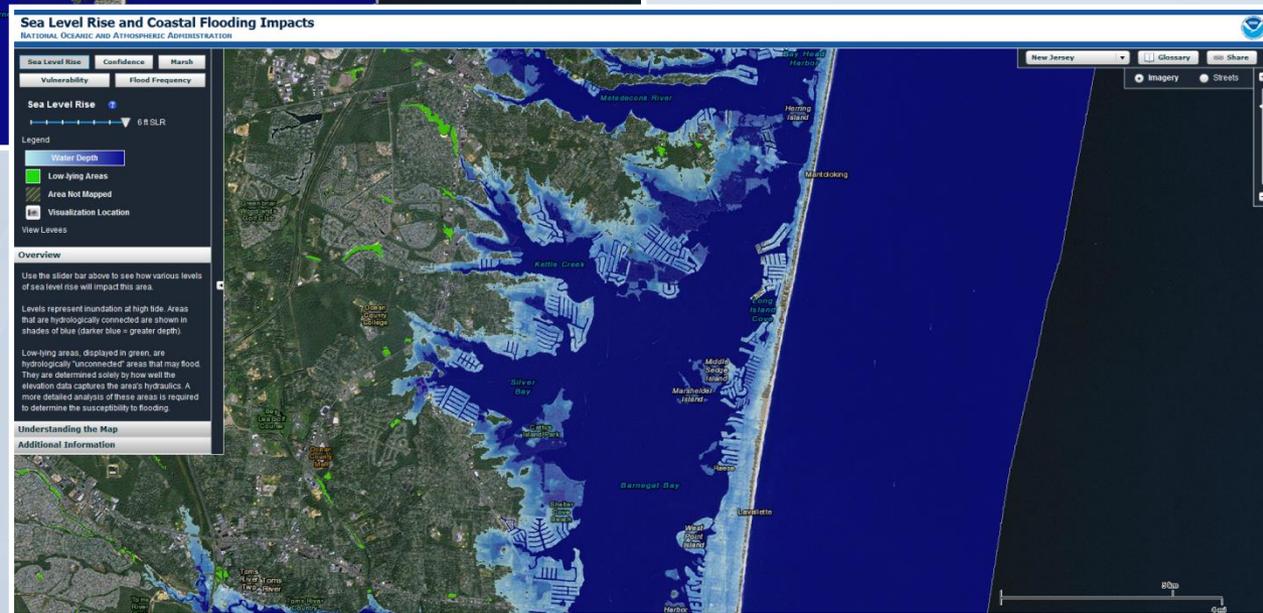
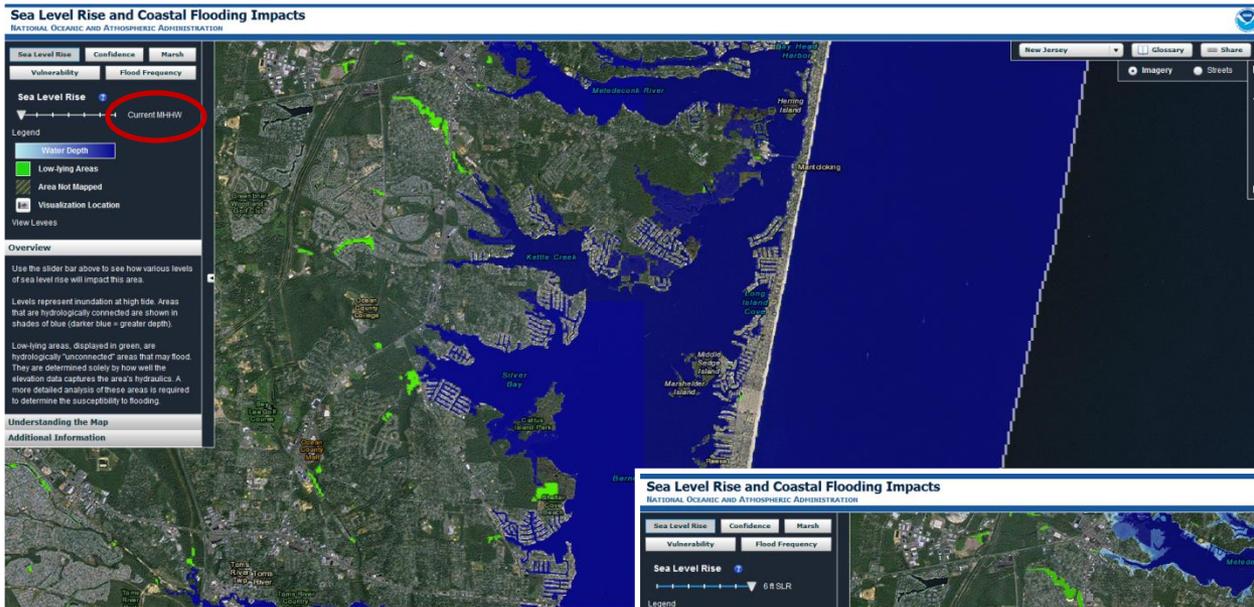


Utilizing VDatum for Digital Elevation Model Creation



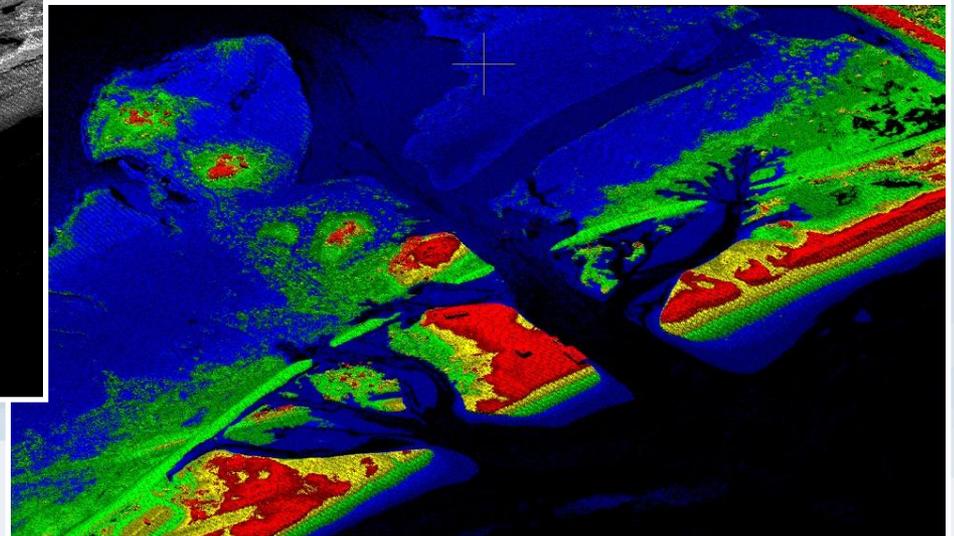
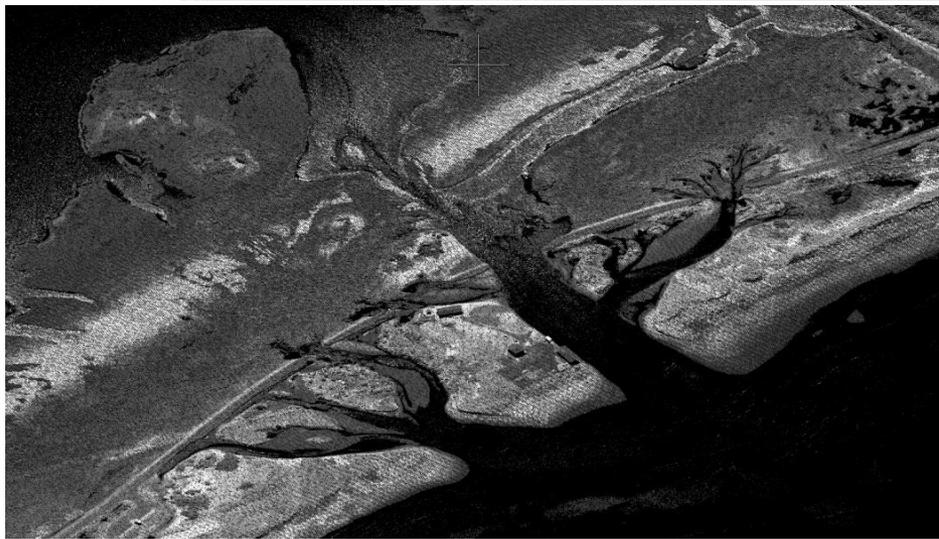
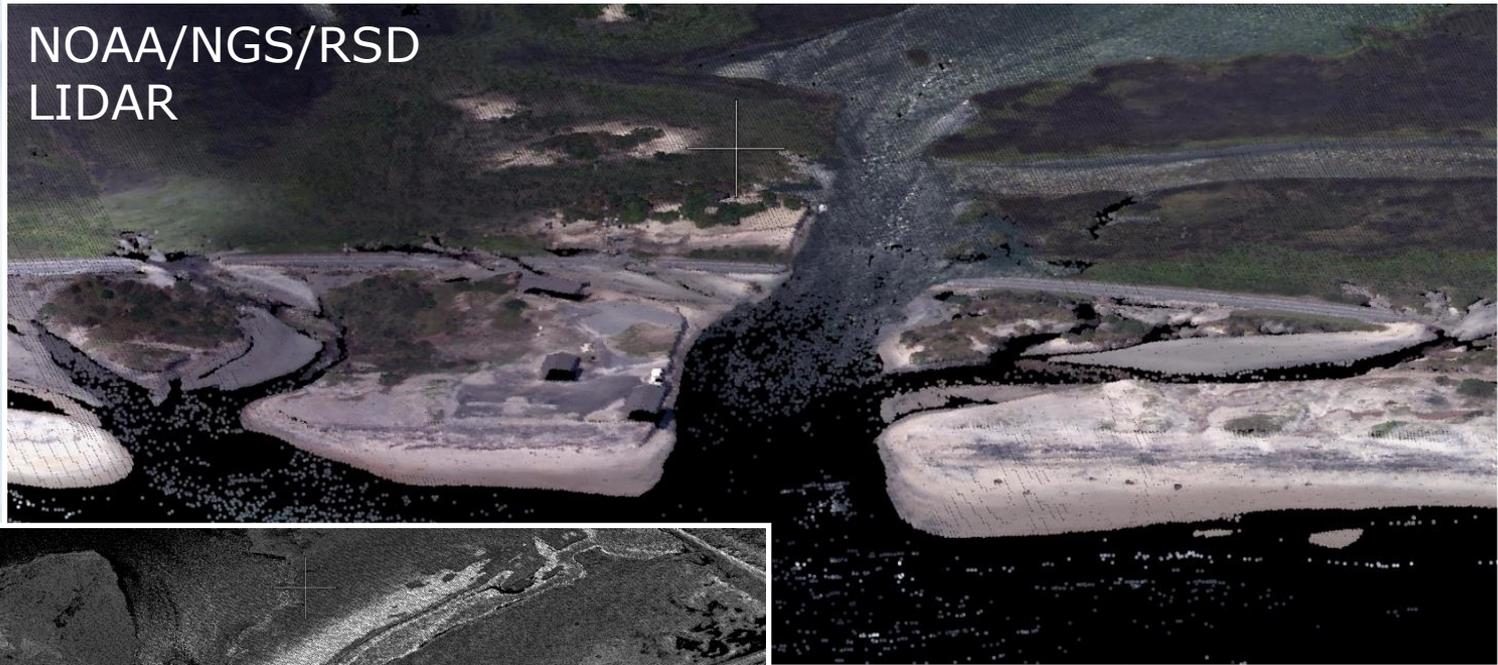
National Oceanic and Atmospheric Administration

Sea Level Rise/Coastal Flooding



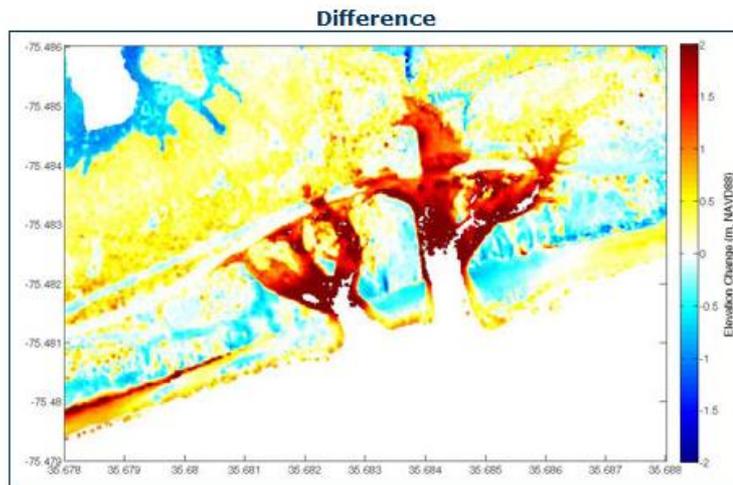
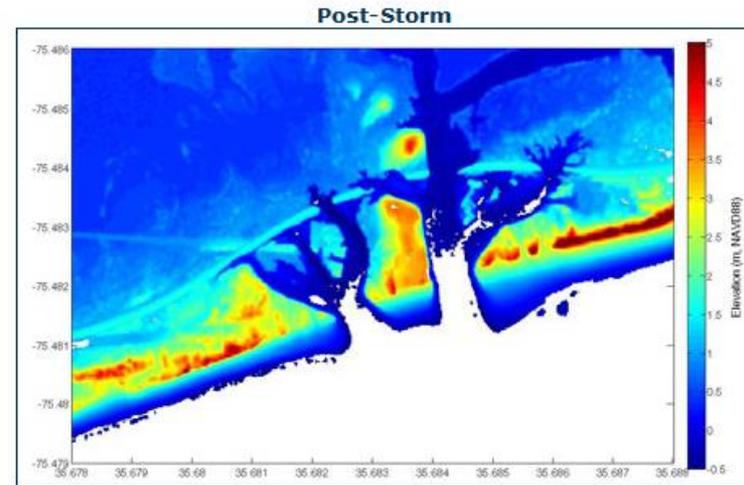
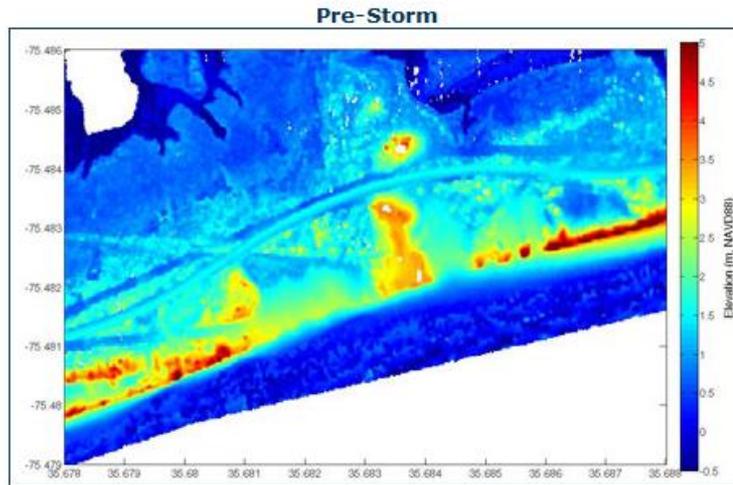
Emergency Response

NOAA/NGS/RSD
LIDAR



National Oceanic and Atmospheric Administration

Emergency Response



Location 5: Lidar topography from November 27-December 1, 2009 (Pre-Storm) and August 28-29, 2011 (Post-Storm) and topographic change (Difference) for a portion of the Outer Banks in the Pea Island National Wildlife Refuge, NC. In the pre-storm image, note the two particularly low elevation areas between a relative high. During the storm, surge and waves were funneled through the lower areas, carving two breaches (post-storm image). The difference image shows the intricate pattern of erosion associated with the formation of the breaches. See [pre- and post-storm photo comparisons](#) for additional discussion.

Courtesy of USGS



National Oceanic and Atmospheric Administration

Additional Applications

- Coastal Inundation/Sea Level Rise/Tsunami Modeling
- Erosion/Accretion/Shoreline Change
- Habitat/Wetland Restoration
- Dredging and Infrastructure Engineering (levees, jetties)
- Floodplain Mapping
- Topobathy DEM Creation
- Civil and Water Works Projects
- Easement and Setback Planning
- Marine Construction
- Coastal Engineering
- Coral Reef Mapping
- Analyzing Storm Impacts
- Real Estate Mapping
- Evacuation Route Mapping
- Site Management
- Insurance Studies
- Hazardous Waste Site Studies
- Groundwater mapping and modeling
- Feasibility Studies and Planning,
- Determining Local, State and National Boundaries
- Permitting
- Analyzing Environmental and Natural Resources
- Emergency Response



Summary

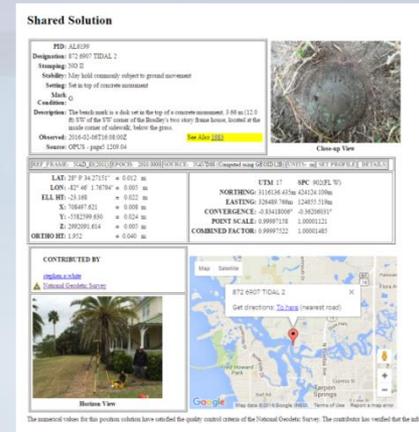
The VDatum transformations tool from NOAA allows us to transform vertical datasets between ellipsoidal, orthometric and tidal datums...

- Assuring data is transformed correctly
- Enabling multiple uses for datasets across applications (Coastal Resilience, Intelligence, and place-based)
- Permitting merging of disparate data sets to a common reference
- And providing transformation uncertainty estimates for intelligent decision-making and analysis.



What we need from you:

- Assistance collecting GPS on tidal benchmarks
- Problems (Software or Models)
- Enhancements



VDatum: Contact Us

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

VERTICAL DATUM TRANSFORMATION

INTEGRATING AMERICA'S ELEVATION DATA

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Contact Us

Thank you for visiting NOAA/NOS's VDatum website. Take our website user survey. We welcome your ideas, comments, concerns, and suggestions.

- [User FAQs](#)
- **General Discussions, Help Requests, Bug Reports, Comments etc..**Please send email to vdatum.info@noaa.gov

For general discussion, please briefly state your concerns in the subject of your message, such as: Tidal modeling, or Software question.

For help requests or bug reports, please provide as much detail as you could, including specific error messages you may be receiving and sample of your data.

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Web site owner: National Ocean Service NOAA Department of Commerce

Last modified: 06/13/2016 15:11:26



Thank You!

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